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WEEKLY 13 July 2024

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MYSTERIOUS GLOBAL CRACKDOWN ON QUANTUM COMPUTERS

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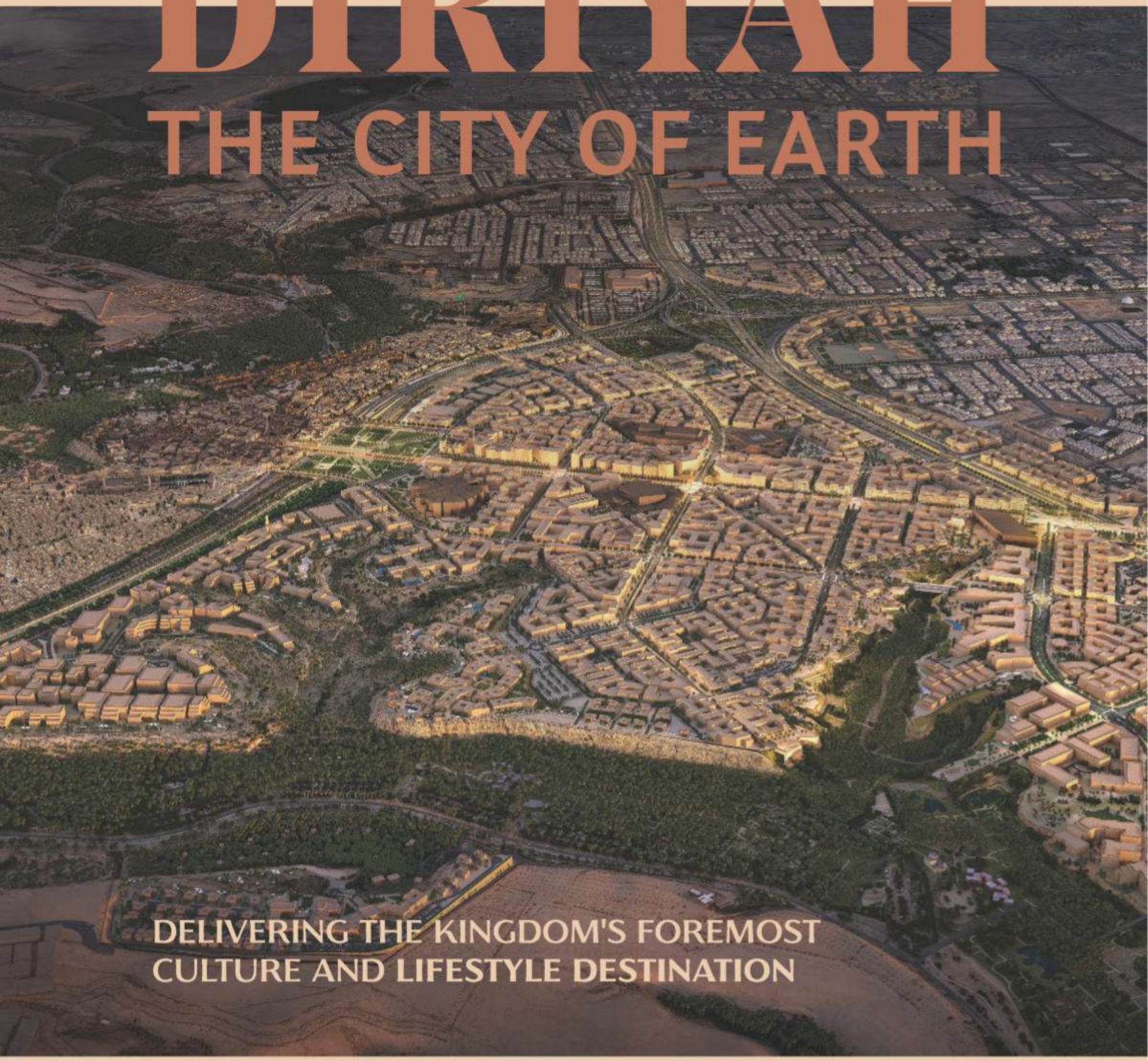

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NS Live

Secrets of gravity

Join cosmologist and pilot Claudia de Rham on a journey through the different meanings of gravity. Following Isaac Newton and Albert Einstein, de Rham is grappling with this most enigmatic force of nature, leading her to the strange conclusion that gravity may have a sense of humour. Find out more at New Scientist Live on 13 October at London's ExCeL Centre.

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Tour

Geology, conservation and culture: Vietnam

Experience tropical jungles, limestone caves and feats of underground engineering in this tour of Vietnam's spectacular geology, wildlife conservation and history. Immerse yourself in local culture and cuisine – from street food to dining like royalty. This 13-day tour begins on 17 August and costs £3699.

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Podcasts

CultureLab

Composer David Ibbett has used audio recordings captured by Mars rovers to create an immersive concert that transforms the sounds of the dusty planet into musical instruments and melodies. In this episode, Ibbett discusses how he composed with the real sounds of winds, dust devils and seismic rumbles to take the listener on an interplanetary journey through the past, present and future of the red planet.

newscientist.com/nspod

SUZI ESZTERHAS/MINDEN PICTURES/ALAMY

Rare scales Feed pangolins at a conservation centre in Vietnam

DAVID STOCK

Gravity falls Trainee astronaut turned physicist tells all about gravity

Video

The science of racism

"What can you do when science and medicine are as biased as the society they treat?" asks science journalist Layal Liverpool in her new book, *Systemic*. We sat down with Liverpool to discuss her own journey navigating the healthcare system as a Black woman, the idea of anti-racist medicine and what really needs to be done to tackle health inequality.

youtube.com/newscientist

Newsletter

Lost in Space-Time

Is the universe a game? Famed physicist Richard Feynman certainly thought so: "'The world' is something like a great chess game being played by the gods". But if it is a game, then who is playing it? And what would it mean to win? Mathematician Marcus du Sautoy explores these questions and more.

newscientist.com/lost-in-space-time

Video

"You're seen as an unreliable narrator of the experiences in your own body"

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Quantum secrecy

Disclosing the rationale for quantum computer regulations would be better for all

IMAGINE if governments around the world announced restrictions on the sale of rulers that are 34 centimetres long. You would be pretty confused, given there doesn't seem to be anything special about that length – and 34cm rulers don't exist.

Such legislation would be ludicrous, but something similar has been enacted for quantum computers in several nations (see page 18). The restrictions – which limit the export of computers with 34 or more qubits, or quantum bits, and error rates below a certain threshold – are puzzling, as such devices have no practical use, according to all published research.

But the very specificity of the number suggests some thought behind it. Clearly, someone, somewhere, is worried about nefarious use of these devices – most likely their potential to break widely used encryption methods – and wants them restricted in the name of national security.

So what is going on? There are two possibilities here: either they are wrong, as scientific evidence suggests, and pointless legislation is now being cut and pasted across the world, or they are right and have now alerted their adversaries that this is a number worth paying attention to. Both possibilities seem counterproductive, but without access to the research behind these restrictions, it is impossible to say.

"Someone, somewhere, wants these devices restricted in the name of security"

One of the great strengths of science is that it is an open endeavour. For all its faults, peer review allows us to harness minds around the world to scrutinise and improve research. Our approach to making policy should be no different.

The Intergovernmental Panel on Climate Change shows just how powerful this can be. By publicly synthesising research, it has allowed policy-makers to understand what needs to be done to tackle climate change – and allowed others to use that evidence base to analyse policy decisions. Equally, published research during the covid-19 pandemic allowed for a public discussion on rules being imposed on us. Simply plucking a number from the air, as seems to be the case with quantum computers, is no way to govern. ▮

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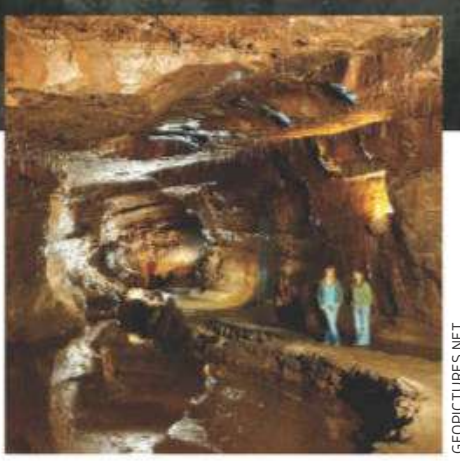
The science of deep time: Brecon Beacons, Wales

9 September 2024 | 3 days



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Join this short break in the stunning Brecon Beacons, to witness the cosmic, geological and human forces that have shaped our lives, and understand humankind's place in the story of Earth. Learn about the science of deep time, the formation and geology of Earth and explore the timeline involved in the creation of our world and the wider cosmos. One of the highlights of this short break is a 4.6-kilometre deep time walk in the Brecon Beacons. You will explore the stunning landscape while listening to an account of the 4.6 billion years of Earth's history. Each metre walked will represent 1 million years of time.

This tour is hosted by journalist and author Richard Fisher. He will be joined by an array of leading deep time, geology and astronomy experts including Martin Griffiths, Thomas Moynihan and Alan Bowring. They will offer a range of fascinating talks and walking seminars over the three days, enabling you to gain an appreciation and understanding of the timelines and processes involved, and the small amount of space and time we occupy in it.

Your base for this short break will be the unique Craig Y Nos, a 1840s gothic castle that has been fully renovated and is located in the Brecon Beacons National Park. The castle and country park sit alongside the upper river Tawe on the edge of the Black Mountain and was owned by 19th-century opera singer Adelina Patti.

This short break is perfect for those that are fascinated by landscapes, cosmology, geology and astronomy.

Highlights include:

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- **Immerse yourself in the landscapes of the Brecon Beacons with a Deep Time guided walk.**

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News

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Old masters
Pig painting is the earliest known narrative art p17

Animals

Stunning in shocking blue

This rare blue frog was found at a wildlife sanctuary in the Kimberley region of Western Australia. Normally, a mix of yellow and blue skin pigments would make the magnificent tree frog (*Litoria splendida*) a vibrant green. But it is thought that this individual has a genetic mutation that means it lacks the yellow, allowing the blue to show through.

JAKE BARKER/AUSTRALIAN WILDLIFE CONSERVANCY

Evolution

Life from a digital primordial soup

Google has shown that virtual life forms can emerge from randomness with no rules or direction, hinting at the process behind biological life on Earth, says **Matthew Sparkes**

A SELF-REPLICATING form of artificial life has arisen from a digital "primordial soup" of random data, despite a lack of explicit rules to encourage such behaviour. Researchers say more sophisticated versions of the experiment may yield more advanced digital organisms, and if they did, this could shed light on the emergence of biological life.

"Physics occurred a lot over a very long time, and it gave rise to some very complicated things"

While the process of evolution is well understood, little is known about how inert molecules first came together to form life. To investigate how humble beginnings can lead to complex ends, Ben Laurie at Google and his colleagues designed experiments where tens of thousands of separate pieces of computer code randomly mingled, combined and executed their instructions over millions of generations.

Because there were no rules to govern how the code samples should change and no rewards for certain behaviour, the researchers expected the population – which was capped at a fixed number – to remain random and do nothing coherent. But to their surprise, they found that the simulation eventually led to the emergence of self-replicating programs that quickly multiplied to hit the population cap. Eventually, new types of replicators emerged that competed for space and occasionally overwhelmed and replaced the previous population, just as biological organisms can outcompete each other (arXiv, doi.org/m676).

This research is far from the first attempt at mimicking life digitally: for example, simulations such as the Game of Life, which has a grid of cells that are either "alive" or "dead" and are governed by simple rules, have shown self-replicating behaviour. Laurie says what makes this work unique is that the system had no formal rules, goals or processes to encourage or kick-start artificial life – it simply arrived. "It all fizzes around and then suddenly: boom, they're all the same," he says.

The experiments may not tell us anything concrete about how biological life began, says Laurie, but they do reveal inherent mechanisms to create complexity from nothing. He believes that complex biological life is merely a result of a similarly long period of random iteration. "I don't think anything magic happened," he says. "Physics occurred, and it just occurred a lot over a very long time, and it gave rise to some very complicated things."

But life on Earth emerged only after "billions of years of massively parallel experimentation", says Laurie, and while he believes that great complexity would emerge from the team's system if scaled-up in size and duration, we would quickly hit the limits of current computers.

"My gut feeling is that if you want more interesting behaviour, if you want things eating each other, or war going on between different species, or complexification that allows sensing of the environment and things like that – which I think would ultimately come – it's going to require so much [computation] that we're not going to practically do it," says Laurie.

Great achievement

Indeed, many of the team's experiments ran for millions of steps before displaying organised behaviour. Laurie says that one instance, running on his laptop, involved processing about 3 billion instructions a second and it still took around half an hour for self-replication to emerge.

Susan Stepney at the University of York, UK, says that the work is fascinating. "Managing to evolve self-replicating programs from random starting points is a great achievement," she says. "This is definitely a great step towards understanding potential routes to the origin of life, here in a medium quite removed from the standard 'wetware' of biology."

Richard Watson at the University of Southampton, UK, says the results are "very cool", but notes they are unlikely to lead to increasingly complex behaviour automatically.

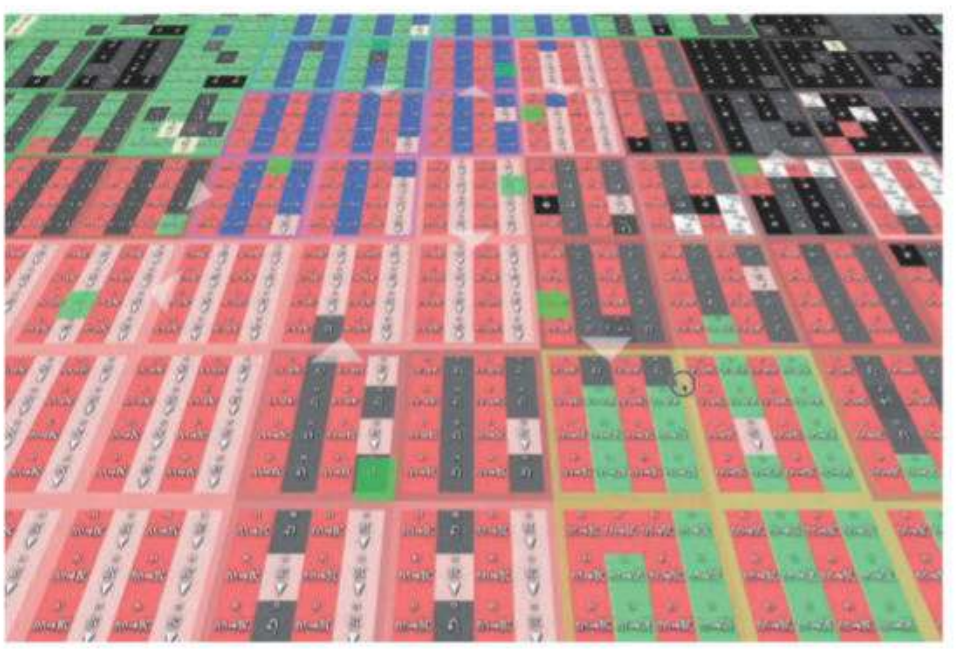
"The complexity, as they measure it, goes up after the onset of the self-replicator. But it's not clear that it 'takes off' in an interesting way," he says. "Self-replication is important, but it would be a mistake to believe it's a magic bullet from which everything else that's exciting about life follows automatically".

Raquel Nunes Palmeira at University College London is also doubtful that the work sheds light on the origin of life on Earth. She likens it to a classic experiment where RNA strands were replicated in a test tube, resulting in the length of the RNA getting shorter and shorter and replication speed getting faster and faster. A very simple form of natural selection was rewarding a lack of complexity, not encouraging greater complexity – the opposite of what is needed to explain the origin of complex life, she says.

"Having infinite copies of something does not guarantee complexity," says Nunes Palmeira. "If you have one thing that just self-replicates and does it faster than everything else, then you're just going to have a system that is completely taken over by that." By contrast, life involves multiple interacting components, including DNA, RNA, proteins and more, she says. "It's a very complex system, and I think we're not that much closer to understanding how it arose de novo by just looking at self-replication." ▮

A visualisation of Google's artificial life forms

GOOGLE



Mathematics

The perfect-sized bowl to store used pistachio shells

Karmela Padavic-Callaghan

ARE you a pistachio fan? We now know the exact size of bowl to best fit discarded shells, thanks to Ruben Zakine and Michael Benzaquen at École Polytechnique in Paris, who often find themselves discussing science while eating the nuts.

The researchers stuffed 613 pistachios into a cylindrical container to determine their "packing density", or the fraction of space taken up by whole nuts in their shells. Then they measured the packing density of the shells alone. In one experimental set-up, the researchers poured the shells into a container and let them fall as they may. In another, they shook them into a denser, more efficient configuration.

Without shaking, the shells took up about 73 per cent of the original packing density. Shaking decreased this number to 57 per cent. This suggests that, with any pistachio container, an additional half-sized container will hold shell refuse as long as you occasionally shake the container while eating.

Zakine and Benzaquen backed up their findings by modelling pistachios and their shells as ellipsoids – three-dimensional shapes resembling squashed spheres – and calculated their packing densities based on mathematical rules. These results confirmed the real-life experiments and suggested the same ratios would work for other container shapes (arXiv, doi.org/m6rc).

Despite these similarities, the researchers found about a 10 per cent discrepancy between the calculations and the real-life measurements.

Zakine says this isn't surprising because pistachios aren't perfect ellipsoids and have natural variations in shape. More broadly, it is tricky to calculate how best to pack objects into containers, he says. ▮

Archaeology

Roman Britain saw a 'modern' kind of economic growth

Michael Le Page

SANG TAN/ASSOCIATED PRESS/ALAMY

Roman coins were used to estimate economic growth

AFTER the Romans conquered Britain in AD 43, the technologies and laws they introduced led to centuries of economic growth of a kind once thought to be limited to modern industrial societies.

"Over that period of about 350 years, you're looking at roughly a two-and-a-half-[fold] increase in productivity per capita," says Rob Wiseman at the University of Cambridge.

It has long been believed that economic growth in the ancient world depended on having more people and more resources, says Wiseman: to increase food production, say, required more land and more farm workers. This is known as extensive growth.

By contrast, economic growth today is driven mainly by increased productivity, or intensive growth. Thanks to mechanisation and better breeds of plants and animals, for instance, more food can be produced from the same area of land with fewer workers.

Some recent studies have challenged the idea that intensive growth occurred only after the industrial age began, inspiring Wiseman and his colleagues to look at growth in Roman Britain from AD 43 to 400.

By looking at how the number of buildings changed over time, the researchers were able to gain insights into how the population of Roman Britain grew. There

"Over 350 years, you're looking at a roughly two-and-a-half-fold increase in productivity"

is a strong relation between the number of buildings and population size, says Wiseman.

To get an idea of economic growth, the team looked at three measures. One was the size of buildings, rather than the number of them. As people grow richer, they build bigger houses, says Wiseman.

Another measure was the number of lost coins found in digs. "These are things that have fallen through the floorboards, or they've been lost in the baths, or something like that," he says. The idea is that the more coins are in circulation, the more are likely to be lost.

The third measure the team looked at was the proportion of crude pottery, such as cooking pots and storage pots, to more ornate pottery like decorated plates. Economic growth requires people to interact more and socialise more, which means "showing off" when guests are present, says Wiseman.

Based on these measures, the researchers found that economic growth exceeded that expected from population growth alone. They estimate that per capita growth was around 0.5 per cent between AD 150 and 250, slowing to around 0.3 per cent between AD 250 and 400 (*Science Advances*, doi.org/m67m).

"What we're able to show is yes, after the Romans arrived, there was definitely intensive growth," says Wiseman. The pace of growth rather than the kind of growth is what probably distinguishes the modern world from the ancient one, he says.

The researchers think that this growth was driven by factors such as the roads and ports built by the Romans, the laws they introduced making trading safer, and their technologies, such as more advanced grain mills and better breeds of animals for ploughing.

"I am convinced that they are right and that, indeed, intensive growth took place in Roman Britain," says Alain Bresson at the University of Chicago, Illinois. ▮

Analysis Nutrition

Is ultra-processed food unhealthy? Here's why no one can agree

While highly processed food is the latest fixation in nutrition, the evidence for how it affects our health continues to point in different directions, says **Grace Wade**

NUTRITION advice is often fickle. In the 1990s, nutritionists blamed fats for rising obesity rates. Then, carbohydrates became the culprit in the early 2000s. The latest refrain is to eat whole foods and avoid ultra-processed ones. Now that is being called into question, too.

The trouble is that simply opting for foods with fewer and less-processed ingredients doesn't guarantee a healthier diet. In fact, as a recent meeting of the American Society for Nutrition in Chicago demonstrates, studies on ultra-processed food are mixed, with researchers there often disagreeing about exactly how these foods affect our health.

For instance, Erikka Loftfield at the National Cancer Institute in Maryland and her colleagues presented work at the meeting showing that people who consumed more ultra-processed food had a greater risk of dying during the period of their study than those who ate fewer such products.

What is the risk?

They came to this conclusion after analysing data from more than 500,000 people in the US. Participants enrolled in the study between 1995 and 1996 and completed a questionnaire asking how frequently they ate certain foods in the past year.

Following up two decades later, the researchers found that the people who ate the most ultra-processed food had a roughly 10 per cent greater chance of dying in this period, even after accounting for diet quality and body mass index.

While this suggests that ultra-processed food increases the risk of dying early, it isn't that straightforward. Other factors could explain the association. For instance, people who take the time to cook meals from scratch may also take the time to exercise or may prioritise their sleep.

If that is the case, then exercise or sleep might be the underlying cause here, not ultra-processed food. Because most studies of ultra-processed food are observational, untangling these effects is extremely difficult.

The other issue is that dietary preferences have changed in the past 30 years. For instance, on average, people in the US now consume significantly less beef and potato and significantly more chicken and cheese than they did in the 1990s. So, we can't assume that participants' ultra-processed food intake remained stable during the study period. Furthermore, research being carried out today can't tell us what will happen to people in 30 years' time because, well, it hasn't happened yet.

"You can't automatically dismiss ultra-processed foods as bad or unhealthy"

But as other work presented at the meeting found, even avoiding ultra-processed food is no guarantee of health. While there isn't a universal definition of what makes a food ultra-processed, most studies refer to the NOVA food classification system, developed by Carlos Monteiro at the University of São Paulo in Brazil. According to this system, ultra-processed foods are those made entirely from ingredients extracted from foods or synthesised in laboratories.

This definition includes foods like store-bought cookies, soft drinks and candy. But it also includes foods that can be part of a healthy diet, like wholewheat breakfast cereals, which are a good source of fibre, iron and other micronutrients, says Allen Levine at the University of Minnesota. "You can't automatically dismiss ultra-processed foods as bad or unhealthy and automatically assume that non-processed foods are healthy."

Levine and his colleagues presented research proving this point, by constructing two seven-day menus made up of similar meals. The key difference was that ultra-processed food constituted 67 per cent of the calories in one menu, but only 20 per cent in the other. Despite this, both menus provided low-quality diets, according to a commonly used metric of diet quality in the US called the Healthy Eating Index. The one with more ultra-processed food scored 44 out of 100, while the one with fewer of these products had a score of 43.

Ultra-processed foods like doughnuts are often high in fat or sugar

SCOTT GRUMMETT/GETTY IMAGES

Uncertain causes

This brings up a crucial point, which is whether ultra-processed food has been linked to poorer health outcomes because it is processed or because it is simply higher in fats, sugars and salt. "If you match [ultra-processed food] to a non-processed [food] using the same set of macronutrients – protein, fat, carbohydrate – why would one be different than the other?" says Levine. "Some people think, 'Oh, it's the food additives', but I don't see a lot of evidence for that."

Until that question is answered, we can't say for sure that ultra-processed food is bad for our health. Otherwise, we risk vilifying foods that many people rely on for quick, easy and low-cost meals. For example, Levine and his colleagues found that the menu formed of mostly ultra-processed food cost about $20 less per day than the one with fewer of these products, all while providing comparable nutrients.

It is also possible to eat a healthy diet made up of mostly ultra-processed food, as a similar study published last year found. Julie Hess at the US Department of Agriculture and her colleagues constructed a seven-day menu with a diet quality score of 86 despite 91 per cent of the calories coming from ultra-processed food.

All of this means that the question of what we should be eating to stay healthy will remain difficult to answer. "Food is a complicated structure," says Levine. "Everybody thinks it's simple. It's not." ▮

Environment

Mining flowers for nickel

A start-up in Albania is farming plants that take up nickel from the soil while also aiming to remove carbon dioxide from the atmosphere, finds **James Dinneen**

ON A recent afternoon in northern Albania, workers gathered armfuls of freshly cut shrubs covered in yellow flowers, leaving them to dry in the sun. This was no ordinary harvest, however. The farm is both a mine, growing plants that accumulate nickel metal in their leaves and stems, and a carbon sink, its soil spread with crushed rocks that remove carbon dioxide from the atmosphere.

"We're able to turn the lowest-grade land in the world into some of the most lucrative land in the world," says Eric Matzner, a co-founder of Metalplant, the start-up behind the flower farm.

The idea of mining with plants isn't new. But Metalplant is combining this "phytomining" with a method of removing CO_2 from the atmosphere called enhanced rock weathering, which involves spreading rock dust on fields. This dust can both capture CO_2 and replenish the nickel taken up by the plants.

Previous harvests have contained about 1 tonne of nickel. From this, to test the process, the firm has extracted less than a kilogram of usable metal. But if the yellow flowers perform as hoped, future harvests could offer a greater supply of carbon-negative nickel that would avoid the worst mining impacts.

Demand for nickel to make electric vehicle (EV) batteries is forecast to double to more than 6 million tonnes per year by 2040. Yet mining and refining it is environmentally destructive and, depending on where and how it is produced, mining a tonne of nickel generates between 10 and 59 tonnes of CO_2.

Phytomining for nickel avoids these problems, but it only works where there is a lot of the metal in the soil. Albania is attracting interest due to the high nickel content of its soils: the rocks that compose its mountains are made up of a mineral called olivine, which contains too little nickel for conventional mining, but enough to accumulate in certain plants. French company Econick now has 100 hectares under cultivation for phytomining in the Baltic states (but without enhanced rock weathering) and is expanding in Malaysia, says Guillaume Echevarria at the firm.

METALPLANT

Above: Metalplant's flower farm in Albania. Below: The firm's co-founder Eric Matzner with bundles of *Odontarrhena decipiens*

"We're able to turn the lowest-grade land in the world into some of the most lucrative"

METALPLANT

Metallic soil is toxic for some flora, but native plants have adapted to it. "They take in nickel like a macronutrient," says Aida Bani at the Agricultural University of Tirana in Albania, who is working with Metalplant. Some species, such as the yellow-flowered *Odontarrhena decipiens* that Metalplant is growing, can accumulate about 2 per cent of their dry weight as nickel.

Metalplant also uses Albania's olivine for its carbon removal. This enhanced rock-weathering technique involves spreading olivine, or another silicate rock like basalt, onto fields. As the rocks dissolve, they react with CO_2 in the atmosphere to form bicarbonate minerals that can store the planet-warming gas for millennia.

In June, Metalplant workers harvested 3 hectares of *O. decipiens*, and this area was then spread with a few dozen tonnes of olivine dust. After drying on the field, the plants will be heated to break down organic material. The ash will then be sent to a lab in Germany, where a chemical process will extract a greenish nickel salt, which can be used in existing EV battery production processes.

Depending on how efficiently the plants accumulated the nickel, the farm should yield between 200 to 400 kilograms of usable nickel per hectare, says Matzner, enough for a handful of EV batteries. He says each tonne of nickel produced this way would be associated with as much as 200 net tonnes of CO_2 removed, depending on how much olivine was put down. Firms that make EVs could then include the resulting carbon-negative metal in their supply chains to offset their overall environmental impact, suggests Matzner.

Yet the amount of nickel that could feasibly be produced is too small to compete with conventional mining, says Marie-Odile Simonot at the University of Lorraine in France, who is involved with Econick. Any environmental benefit "also depends on the way it is done", she says. Expanding phytomining farms on ecologically sensitive land could have the same environmental impacts as any other form of agriculture, for instance. Metalplant's approach – using olivine dust from a nearby quarry – also doesn't avoid conventional mining.

"I'm still worried about mining, extracting, crushing, transporting and spreading something," says Echevarria. He says adding the extra rock may be unnecessary given that supplies of nickel in the soil will be recharged over time by natural erosion and runoff. ▮

Food production

Synthetic butter made from CO_2 shows a way to use less land to feed the world

Madeleine Cuff

A NEW type of dietary fat that doesn't require animals or large areas of land to produce could soon be on sale in the US as researchers and entrepreneurs race to develop the first "synthetic" foodstuffs.

US start-up Savor has created a "butter" derived made from carbon in a thermochemical system closer to fossil fuel processing than food production. "There is no biology involved in our specific process," says Kathleen Alexander at the firm.

Instead, its product relies on the carbon in coal, methane or carbon dioxide as a starting material. The petrochemical industry uses such inputs to create syngas – a blend of carbon monoxide and hydrogen – which is then turned into long-chain hydrocarbons in what is called the Fischer-Tropsch process.

Savor takes these hydrocarbons and oxygenates them to create fat precursors called fatty acids, then adds glycerol to form triglycerides, a type of fat found in many foods.

To turn that into butter, Savor adds water and an emulsifier, then beta carotene for colour and rosemary oil to add a "grassy" flavour. "It tastes like butter," says Alexander, speaking to *New Scientist* at the Breakthrough Energy Summit in London in June.

"If we had an emergency, this kind of food could feed the whole planet for a really long time"

Synthetic fats could like this revolutionise the food system by providing calories while freeing up land for conservation and carbon storage, says Alexander. Products made this way could also provide a food source in the event of an environmental disaster. "If we had an emergency, this could feed the whole planet for a really long time," she says.

Savor's first consumer offering will be butter, in part because of its high price point compared with other fats. The firm is currently working to secure regulatory approval for its product in the US and expects to compete on cost with dairy butter. But Alexander suggests Savor's alternative fat could also replace other ingredients including palm oil and coconut oil, which are drivers of deforestation in tropical countries.

However, getting the public to adopt synthetic fats into their diet may be tricky, admits Alexander, particularly in the wake of scandals around artificial trans fats. "We want to engage with people about why we think it is good for the planet," she says.

An analysis published last year, co-authored by Alexander, suggested synthetic fats could have less than half the carbon footprint of those made using agricultural systems.

If synthetic fat production is powered with renewable energy and uses captured carbon as a feedstock, it could be "dramatically better than anything we are doing in agriculture today", says Steven Davis at Stanford University, California, the lead author of that study.

Juan García Martínez at the non-profit Alliance to Feed the Earth in Disasters says Savor's process for producing synthetic fat could "produce large amounts of food while avoiding risks that threaten traditional agriculture, such as climate change, environmental degradation, pathogens and pests". ▮

Astrochemistry

Weird 'dangling' ice seen in space for the first time

FLUFFY ice that could help create the molecular building blocks for life has been spotted in space.

Normally, ice has a solid crystal lattice structure, with all of its H_2O molecules strongly held together via their hydrogen and oxygen atoms. But when ice isn't fully compacted, such as in powdery snow, some of these molecules can have loose ends, so that only one hydrogen atom is bound up in the lattice while the other dangles out.

These so-called dangling bonds produce very specific signatures of light that scientists have measured in the lab. But finding the same signatures in space, such as from the ice-covered dust grains that go on to form stars and planets, has proven tricky, as Earth's atmosphere absorbs these light frequencies.

NASA, ESA, CSA, M. ZAMANI; SCIENCE: F. SUN, Z. SMITH, ICE AGE ERS TEAM

The ice was found in the Chamaeleon I Cloud, a star-forming region

Now, Jennifer Noble at Aix-Marseille University in France and her colleagues have used the James Webb Space Telescope to spot the light from dangling bonds in a vast star-forming region around 500 light years away from Earth, known as the Chamaeleon I cloud.

Noble and her colleagues trained JWST on a large region of Chamaeleon I and found two frequencies that were almost exactly the same as what was seen in the lab, just slightly higher. One of them appears to be from light reflected by ice with dangling bonds, while the other appears to be reflected from ice that has bonded to other molecules such as carbon monoxide (*Nature Astronomy*, doi.org/m6q7).

The interactions between light and ice dictate which molecules are made as planets form, says Martin McCoustra at Heriot-Watt University, UK, making these bonds crucial to learning about the chemistry that led to life on Earth. "These little icy snowballs are essentially the chemical nanofactories in which complex organic molecules can be made." ▮

Alex Wilkins

Gene therapy targets brain tangles

A one-off treatment could prevent the formation of protein aggregations linked to Alzheimer's and other neurodegenerative conditions, says **Michael Le Page**

IT MIGHT be possible to treat a range of neurodegenerative conditions, including Alzheimer's disease, with a one-time gene therapy that makes brain cells produce antibodies. Tests on human "mini-brains" growing in a dish show that these antibodies can reduce levels inside brain cells of the tau protein associated with these diseases.

"We're looking at, hopefully, a 'one and done' approach," says David Butler at the Neural Stem Cell Institute, a non-profit organisation in New York.

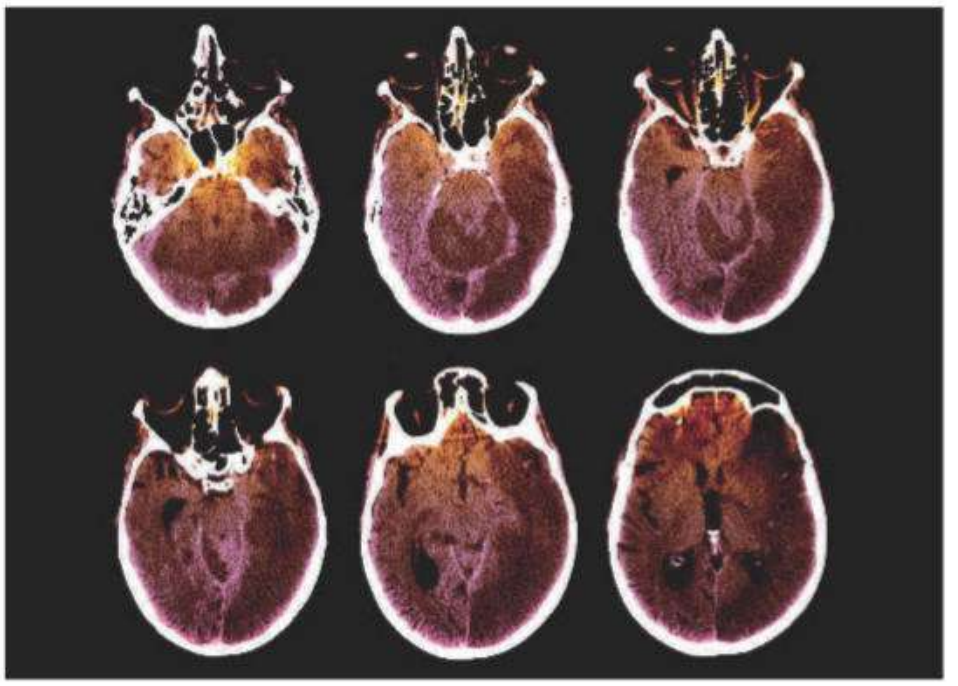
In several neurodegenerative conditions, abnormal levels of a protein called tau accumulate in brain cells and clump together to form what are known as tau tangles. Studies suggest that lowering the levels of tau inside cells can halt disease progression and even reverse some symptoms if done early enough.

However, lowering levels of a protein inside brain cells is extremely difficult. Almost all the tau-targeting treatments tested in people so far only affect tau protein outside cells, which might be why they haven't proved effective.

One way to lower tau levels inside cells is to reduce production of the protein. This can be done with what are called antisense molecules, which bind to the messenger RNAs that carry the instructions for making tau proteins and prevent them from being read.

Intracellular antibodies

Last year, a company called Biogen reported promising results from initial human trials of a tau-targeting antisense treatment called BIIB080. It said there were "favorable trends" in measures of cognitive abilities



ZEPHYR/SCIENCE PHOTO LIBRARY

CT scans showing brain atrophy due to Alzheimer's disease

and scans showed a reduction in tau tangles. Further trials are now getting under way.

However, for antisense molecules to reach the brain, they must be injected into the cerebrospinal fluid, which involves a procedure called a lumbar puncture. And because the antisense molecules don't last that long, people need to have regular lumbar punctures. This is a major disadvantage given the pain, cost and potential side effects of the procedure.

Butler's approach is to instead get rid of excess tau using an intracellular antibody, or intrabody.

Normally, antibodies circulate in the blood, targeting pathogens like viruses. Intrabodies are modified versions of antibodies designed to bind to specific molecules inside cells.

Because antibodies are large proteins that can't get through cell membranes, they must be made inside cells. This means using viruses to carry DNA coding for intrabodies into cells. "We deliver the intrabody as a gene therapy and then the cells will make the therapeutic," says Butler.

Neurons with the extra DNA will keep making intrabodies indefinitely, so the treatment is permanent.

Butler's team has designed an intrabody that does two things. One section binds to the part of the tau protein that joins with other tau proteins to form tangles. This stops these proteins from adding to existing tangles.

"Studies suggest that lowering the levels of tau protein inside cells can halt disease progression"

The second section links up with structures known as proteosomes that destroy damaged or excess proteins, resulting in the removal of the tau protein that the intrabody has bound to. In other words, the intrabodies drag tau proteins into the cell's recycling bin.

In tests in human nerve cells and human brain organoids, or mini-brains, the team has shown that these intrabodies can reduce tau levels and improve survival of cells (bioRxiv, doi.org/m67t).

While the intrabodies aren't designed to directly target tau tangles that have already formed, Butler thinks that once tau levels have been reduced, cells are able to clear up the tangles themselves.

"Intrabodies would have advantages over current approaches," says Michel Goedert at the University of Cambridge.

DNA delivery

He agrees that reducing tau levels will probably clear up existing tau tangles. "[Antisense molecules] against tau work that way," says Goedert. But delivering the DNA coding for intrabodies to the brain is a major challenge, he says.

One worry, especially with an effectively permanent gene therapy, is that the treatment could work too well. Tau proteins have important roles in brain cells, so lowering tau levels too far could have adverse consequences. For this reason, Butler's team has created variants of the intrabody with differing levels of effectiveness.

"We've developed this controlled degradation where we can set the level of clearance to a desired level," says Butler.

Animal studies are now getting under way and Butler hopes human trials could begin in two or three years if all goes well.

Other teams are working on similar therapies. One related approach is to add the cellular equivalent of "recycle me" labels to tau proteins, for instance. But Butler says these labelled tau proteins can still end up in tangles.

He thinks it is more effective to deliver tau proteins directly to recycling bins, rather than relying on cells to do it. "It's a very simple and clean approach." ▮

Analysis Water infrastructure

Thousands of US dams may be unprepared for extreme rain

Many were designed using estimates of precipitation based on outdated science, which makes them vulnerable to extreme weather, says **James Dinneen**

THE near failure of a century-old dam in Minnesota has drawn renewed attention to the vulnerability of ageing water infrastructure in the US. Thousands of dams are in a poor condition, and many were designed based on estimates of extreme rain that may now be outdated as climate change drives stronger precipitation in some parts of the country.

"The state of the infrastructure is such that it's not able to resist even minor events in many cases," says Upmanu Lall at Arizona State University.

Of the country's more than 90,000 dams, about 25,000 are considered "hazardous" – they are large enough to pose a significant danger to people if they were to fail. Within this category, the condition of more than 7000 dams isn't known, according to the National Inventory of Dams. And more than 4000 were deemed to be in a poor or unsatisfactory condition at their last inspection.

One example is the 114-year-old Rapidan dam in south-eastern Minnesota. On 24 June, following days of heavy rain that caused widespread flooding in the US Midwest, the swollen Blue Earth river jumped its banks at the dam. As water poured around a support structure, county officials warned that the dam was in "imminent failure condition" if the floodwater eroded the rock keeping the concrete structure in place.

A day later, the flow of water had lessened, and the main structure of the dam appeared to be stable. But researchers say the close call illustrates how a combination of unusual precipitation and disrepair could lead to disaster.

"You've got the health of the dam, and then you've got the hazard," says James Smith at Princeton University.

Even if dams are in good condition, they may still be vulnerable to extreme events that weren't accounted for by the engineering standards that have long been used to design them in the US. "The existing procedures reflect remarkable engineering judgement", says Smith, but they relied on an understanding of precipitation that is now outdated.

25,000
dams in the US would pose significant danger if they failed

For nearly a century, the most hazardous dams – and other infrastructure like nuclear power plants – have been designed to withstand the most extreme precipitation events deemed possible in a given area, based on a calculation of "probable maximum precipitation", or PMP. This is usually determined using a statistical estimate from storms in the historical record. It is used to design safety mechanisms such as spillways, which act as emergency release valves to prevent water from going over the top of a dam.

But in a recent study from the US National Academy of Sciences, Smith and his colleagues found that the way these PMP estimates are calculated is based on flawed science and may be inadequate to capture extreme precipitation hazards in a changing climate.

The nearly 200-page report provides detailed recommendations for how to revise estimates of extreme precipitation. Using physical climate models rather than records of past storms, for instance, would ensure estimates reflect our best understanding of how the atmosphere works, as well as the influence of a changing climate, says Smith.

About 15 states have already carried out such reassessments of extreme precipitation hazards and begun to update affected infrastructure, says Bill McCormick at the Association of State Dam Safety Officials. But "there's a lot that hasn't been done", he says.

Inadequate upkeep

Dams that are in disrepair or operated incorrectly can also fail as a result of less extreme precipitation, says Lall. "If your infrastructure is ready to fail, the fact that you designed it for a 1000 or 10,000-year event that you miscalculated is kind of irrelevant."

That seems to have been the case at the Rapidan dam. The precipitation that drove its near failure seems not to have exceeded the PMP estimates for the area, says Bill Kappel at Applied Weather Associates, a consultancy in Colorado. But debris in the river may have plugged the spillway, leaving excess water nowhere to go but around the dam.

In fact, in an analysis of more than 600 dam failures in the US since 2000, Lall and his colleague Jeongwoo Hwang at North Carolina State University found most of them weren't associated with particularly extreme rainfall.

Rather, the study, which hasn't yet been peer-reviewed, found they more often occurred during a moderate rainfall event following a stretch of unusually wet days (Research Square, doi.org/m6qz).

Such sustained wet weather can soak the soil, leading to more runoff. Dam operators hoping to save water may also have kept water levels too high to adequately respond to flooding in some cases, says Lall. "This is happening because we are not paying attention," he says. ▮

BEN BREWER/BLOOMBERG VIA GETTY IMAGES

High water levels at the Rapidan dam in Minnesota in June

Zoology

New snake discovered

The blue-lipped green pit viper has been recognised as a new species

Penny Sarchet

THIS multicoloured venomous snake, found in dry tropical forests in central Vietnam, has been recognised as a new species. Dubbed the blue-lipped green pit viper (*Trimeresurus cyanolabris*), it has a bright, grass-green body, yellow eyes, a brick-red tail and blue lips, chin and throat.

The snake, which feeds on small frogs and lizards, is most active at dusk and after nightfall, spending the day perched on branches or in the hollows of trees near streams.

***T. cyanolabris* is one of 50 closely related Asian species of pit viper and can be distinguished by its colours and smaller size. Sabira Idiiatullina at Moscow State University in Russia and her colleagues used genetic analysis to confirm that the snake is a distinct, previously unrecognised species and that its closest known relative is the red-eyed *Trimeresurus rubeus* (*Zootaxa*, doi.org/m6m2).** ▮

NICK POYARKOV

Health

Your face temperature can reveal your age

SUBTLE changes in the heat patterns of people's faces can show how old they are and flag medical conditions, such as high blood pressure and diabetes.

Jing-Dong Han at Peking University in Beijing, China, and her colleagues used a commercial, hand-held thermal imager to capture facial heat readings and 2D images of more than 2800 Han Chinese volunteers during their annual health check-ups in Jidong between 2020 and 2022.

Participants, who were aged between 21 and 88 years old and included a fairly even mix of men and women, posed for the imaging in a temperature-controlled room while they were calm.

The researchers then created software that combined the 2D images with the heat maps to make one thermal facial image for each person.

Han and her colleagues found clear patterns of heat distribution related to ageing. For example, the nose temperature drops, starting at about the age of 50 in women and by about 60 in men, whereas the temperature of the area around the eyes increases.

The team trained an artificial intelligence model to recognise these patterns and then tested it on another 75 volunteers with no known health issues. It guessed their ages to within five years using just the facial heat patterns.

Studying a further 57 volunteers aged between 25 and 78 and including blood sample analyses revealed a link between increased temperature around the eyes and a rise in cellular activity that can occur with inflammation.

"The nose temperature drops, starting at about the age of 50 in women and by about 60 in men"

Han and her colleagues then tested their AI on people with various metabolism-linked issues and found that some conditions – like diabetes, high blood pressure in women and fatty liver disease – lead to an acceleration of the facial heat changes seen as a result of ageing. In fact, the AI discovered that people with diabetes have thermal patterns consistent with unaffected people who are an average of 6.3 years older (*Cell Metabolism*, doi.org/m6m4).

In addition, these people had disease-specific thermal changes – like higher temperature in the cheeks – that set them apart from people who were just older.

The system will need to be validated in people of other ethnicities, says Han, but if it works, deploying an AI to detect metabolic conditions using facial heat maps "would be fairly quick and straightforward". ▮

Christa Lesté-Lasserre

Technology

Viruses can spread by using ChatGPT

Chatbots can be abused by malware to help them propagate via emails

Chris Stokel-Walker

A COMPUTER virus can use ChatGPT to rewrite its code to avoid detection, then write tailored emails that look like genuine replies, spreading itself in an email attachment.

As well as producing human-like text, large language models (LLMs) – the artificial intelligences behind chatbots like ChatGPT – can also write computer code. David Zollikofer at ETH Zurich in Switzerland and Benjamin Zimmerman at Ohio State University are concerned that this ability could be exploited by viruses that rewrite their own code, known as metamorphic malware.

To see if LLMs could be used in this way, Zollikofer and Zimmerman created a file that can be seeded onto a computer via an email attachment. From there, the software can access ChatGPT and then rewrite its own code to evade detection.

"We ask ChatGPT to rewrite the file, keeping the semantic structure intact, but changing the way variables are named and changing the logic a bit," says Zollikofer. This adaptation allows the altered virus to evade routine antivirus scans once the original format has been identified.

"We are only just starting to see the potential for chatbots to be used for nefarious purposes"

Once the virus is rewritten by ChatGPT, the program opens up Outlook in the background of Windows, without the user knowing, and scans the most recent email chains. It then takes the content of those emails and prompts ChatGPT to write a contextually relevant reply, referencing an attachment – the virus – in an innocuous way.

For example, if the program finds a party invitation in your email, it might reply accepting the request and describing the attachment as a playlist of suitable party music. "It's not something that comes out of the blue," says Zollikofer. "The content is made to fit into the existing content."

In their experiments, there was about a 50 per cent chance that the chatbot's alterations would cause the virus file to stop working. Occasionally, the chatbot realised it was being put to nefarious use and refused to follow the instructions. But the researchers say the virus would have a good chance of success if it made five to 10 attempts to replicate itself in each computer (arXiv, doi.org/m6mx). OpenAI, the maker of ChatGPT, didn't respond to a request for comment.

"I think we should be concerned," says Alan Woodward at the University of Surrey, UK. "There are various ways we already know that LLMs can be abused, but the scary part is the techniques can be improved by asking the technology itself to help. I think we are only just starting to see the potential for LLMs to be used for nefarious purposes."

He is unsure if we know how to defend against the threat. "I think a research area that needs to be spawned rapidly is how to counter these types of misuses. Perversely, it may be that LLMs can help us."

Zollikofer agrees that AI could help. "It's a sort of balance," he says. "The attack side has some advantages right now, because there's been more research into that." But chatbots could also be built into the defence. ▮

Marine biology

Warm waters stop shark eggs from hatching

EGG-LAYING sharks around the globe could take a big hit to their populations by the end of the century as ocean warming and acidification destroy their embryos.

Noémie Coulon at the French National Museum of Natural History and her colleagues have subjected the eggs of the small-spotted catshark (*Scyliorhinus canicula*) to various ocean conditions in tanks in the lab.

These common sharks are found in the Mediterranean Sea and the north-east Atlantic and are among the roughly 40 per cent of sharks that reproduce by laying a tough, leathery egg case that contains an embryo.

NOÉMIE COULON

A small-spotted catshark embryo in an egg

The first test created conditions for a "middle-of-the-road" climate scenario with a temperature rise of 2.7°C above pre-industrial levels, and an associated drop in pH – as the ocean soaks up carbon dioxide from the atmosphere – of 0.2 by the year 2100.

The second scenario – in which the world continues to rely heavily on fossil fuels – predicts a temperature rise of 4.4°C and a drop in pH of 0.4 by the end of the century. The third was a historical baseline, recreating the water temperature and pH in the shark's habitats from 1995 to 2014.

They simulated the conditions over four months as the embryos developed and found dramatic differences in hatching success. In the baseline and the middle-of-the-road scenarios, about 82 per cent of the eggs hatched. But in the warmest scenario, only five of 45 embryos survived – a nearly 90 per cent loss (*Marine Environmental Research*, doi.org/m6mz).

"We were deeply shocked by the high mortality rate," says Coulon. "It would probably cause population collapse."

Even short periods of warmth – such as an especially warm August – were enough to cause hatching failure. Coulon expects that more than 100 egg-laying shark species could be affected, including endangered and vulnerable ones like nursehounds. ▮

Corryn Wetzel

Materials

Complex mazes found in structure of bizarre crystals

Matthew Sparkes

AN ALGORITHM designed to find the most efficient path from atom to atom in a bizarre kind of crystal turns out to produce incredibly intricate mazes. The method could also help us design better catalysts and improve a type of microscopy.

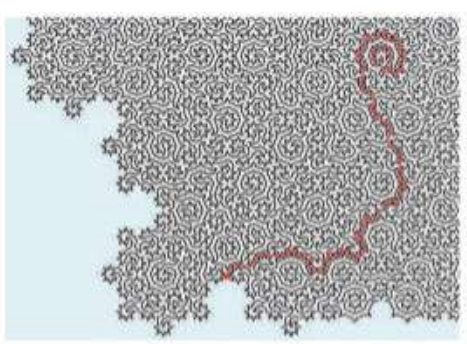
This involves quasicrystals, whose atoms occur in repeating forms like an ordinary crystal, but with more complex and unpredictable symmetry.

"Quasicrystals have all these symmetries that couldn't possibly exist in [normal] crystals," says Felix Flicker at the University of Bristol, UK. To explore further, he and his colleagues have developed an algorithm to quickly create a route that touches every atom in a quasicrystal once, and only once. The diagrams of these routes form beautiful, maze-like structures.

Creating such a route is what is known as an NP-complete problem, one that becomes exponentially more complex as the number of atoms increases. But the team found that for some quasicrystals the problem is unexpectedly simple (*Physical Review X*, in press).

"That was very surprising because that problem in general is known to be essentially impossible to solve," says Flicker. This method could lead to faster scanning tunnelling microscopy, used to image materials at the atomic level, and the design of better crystalline catalysts. ▮

Part of a maze made by an algorithm that visits each atom in a quasicrystal, and a route out of it (in red)

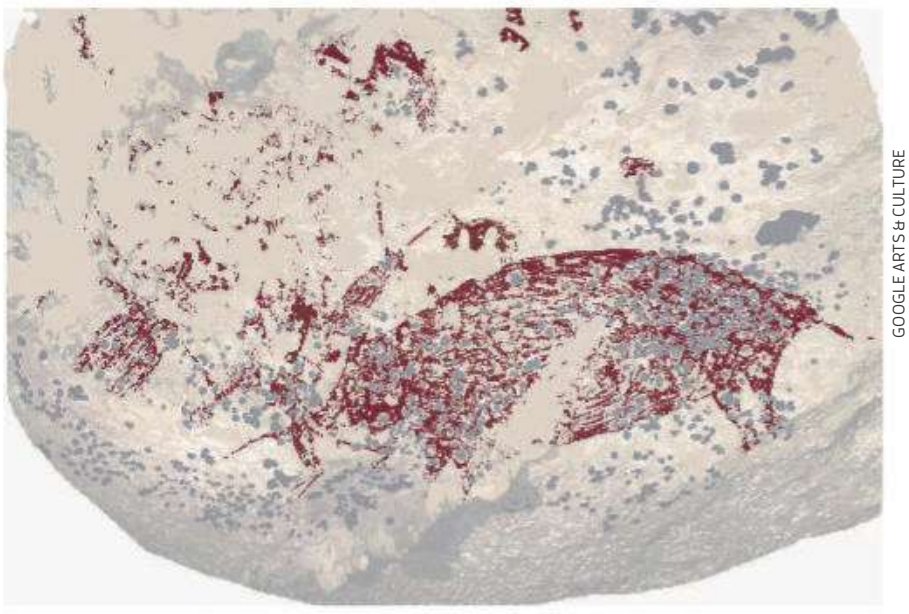


UNIVERSITY OF BRISTOL

Archaeology

50,000-year-old pig picture is the oldest known narrative art

James Woodford



GRIFFITH UNIVERSITY

GOOGLE ARTS & CULTURE

Left: tracing of a painting showing a pig and human-like figures from a cave in Karampuang Hill (above) on Sulawesi in Indonesia

A PAINTING of a pig with human-like figures in an Indonesian cave is at least 51,200 years old, making it the world's earliest known example of representational art.

"We like to define ourselves as a species that tells stories, and this is the oldest evidence of that," says Maxime Aubert at Griffith University, Gold Coast, Australia.

The pig artwork was discovered in 2017 on the ceiling of the limestone cave of Leang Karampuang on the island of Sulawesi. In 2019, Aubert and his colleagues dated a hunting scene from a nearby cave named Leang Bulu' Sipong 4 to a minimum of 43,900 years old.

Now, they have used a new, more accurate technique to estimate the ages of both artworks. They say the image at Leang Bulu' Sipong 4 is more than 4000 years older than previously thought – and the Leang Karampuang art is even older. The artworks at both locations are at least 10,000 years older than the oldest European rock art, says Aubert.

Modern humans, *Homo sapiens*, had reached Australia by 60,000 to 65,000 years ago, so we know they were in the region at this time, he says. "We assume these paintings were made by modern humans."

In the same caves, there are depictions of creatures with human and animal attributes, indicating spiritual beliefs.

Storytelling art

"This rock art is not just small symbols," says team member Renaud Joannes-Boyau at Southern Cross University in Lismore, Australia. "They were actually painting hunting and life scenes, and they were already telling stories with their art, living in a spiritual world and trying to make sense of the environment around them. That tells us a lot about the evolution of *Homo sapiens*."

The previous method of dating the art relied on the chemical extraction of samples and a large portion of rock had to be crushed and destroyed.

In the new technique, a 5-millimetre-diameter core is extracted from the crust on the rock. From the surface of this core, material less than half the thickness of a human hair is removed by a laser and tested to measure the decay of isotopes. Once this is done, the core can be plugged back into the rock art, resulting in little destruction (*Nature*, doi.org/m6k5).

Joannes-Boyau says the technique is likely to lead to major revisions of rock art history around the world.

Kira Westaway at Macquarie University in Sydney, Australia, says the work provides a more accurate assessment of when the Sulawesi art was painted. "This is hugely significant, when the original age was already considered groundbreaking," she says. "This has massive implications for our understanding of the capabilities of the early artists moving through Indonesia and the type of skills and tool kit they already possessed when entering Australia."

H. sapiens probably wasn't the only species with the capacity for complex symbolic practices, says Martin Porr at the University of Western Australia. "It is very likely that other hominins at least had some capabilities in this respect, as can be inferred from the highly sophisticated material culture of Neanderthals." ▮

Technology

The mysterious quantum export deal

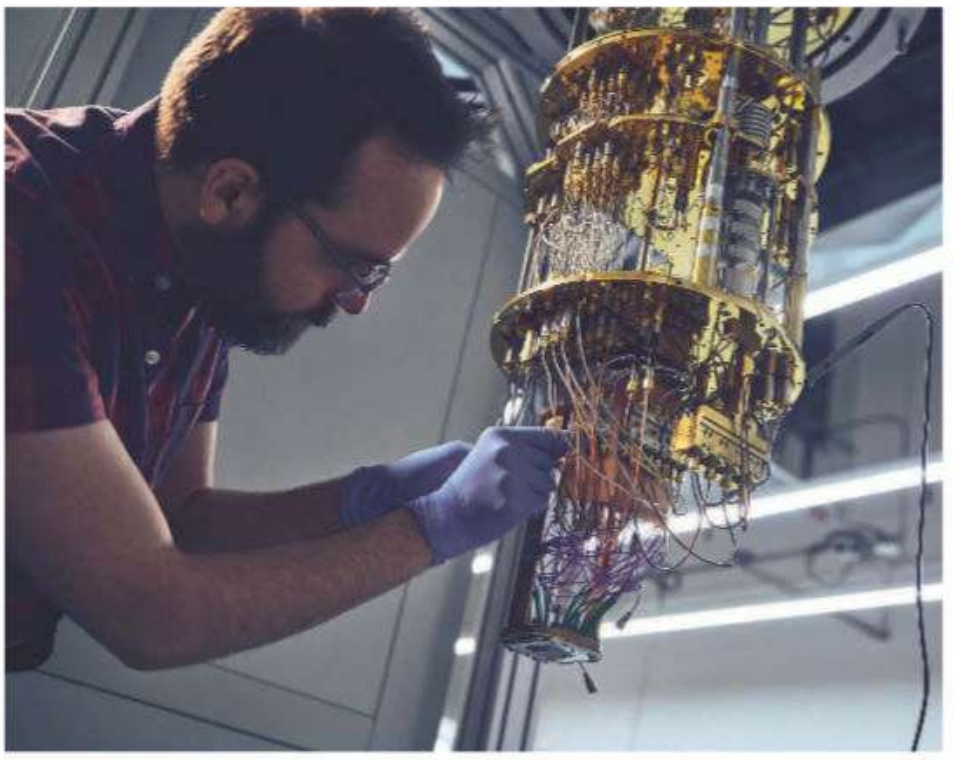
Identical wording placing limits on the export of quantum computers has appeared in regulations for several nations – which can be traced to secret international discussions, finds **Matthew Sparkes**

PRIVATE international talks have resulted in several governments worldwide imposing identical export controls on quantum computers. Although these computers theoretically have the potential to threaten national security by breaking encryption techniques, even the most advanced ones currently in public existence are too small and too error-prone to achieve this, rendering the bans seemingly pointless.

The UK is one of the countries that has prohibited the export of quantum computers with 34 or more quantum bits, or qubits, and error rates below a certain threshold. The intention seems to be to restrict machines of a certain capability, but the UK government hasn't explicitly said this. A *New Scientist* freedom of information request for a rationale behind the numbers was turned down on the grounds of national security.

France has also introduced export controls with the same specifications on qubit numbers and error rates, as has Spain and the Netherlands. Identical limits across European states might point to a European Union regulation, but that isn't the case. A European Commission spokesperson told *New Scientist* that EU members are free to adopt national measures, rather than bloc-wide ones, for export restrictions. "Recent controls on quantum computers by Spain and France are examples of such national measures," they said. They declined to explain why the figures in various EU export bans matched exactly, if these decisions had been reached independently.

A spokesperson for the French embassy in London told *New Scientist* that the limit was set at a level "likely to represent a cyber risk". They said that the controls were the same in France, the UK, the Netherlands and Spain because of "multilateral negotiations conducted over several years under the Wassenaar Arrangement".



TORY WILLIAMS/SEEQC VIA REUTERS

Export of quantum computers like this one is being restricted by many countries

"The limits chosen are based on scientific analyses of the performance of quantum computers," the spokesperson told *New Scientist*, but they declined to comment further.

The Wassenaar Arrangement is a system adhered to by 42 participating states, including EU members, the UK, the US, Canada, Russia, Australia, New Zealand and Switzerland, that sets controls on the export of goods that could have military applications, known as dual-use technologies. Canada has also implemented identical wording on 34 qubits into a quantum computer export ban.

34

Having this many qubits or more makes quantum computers fall foul of new export rules

42

Number of nations signed up to the Wassenaar Arrangement

New Scientist wrote to dozens of Wassenaar states asking about research on the level of quantum computer that would be dangerous to export. Only a few responded.

"I have no idea who determined the logic behind these numbers"

"We are closely observing the introduction of national controls by other states for certain technologies," said a spokesperson for the Swiss Federal Department of Economic Affairs, Education and Research. "However, existing mechanisms can already be used to prevent in specific cases exports of such technologies."

"We are obviously closely following Wassenaar discussions on the exact technical control parameters relating to quantum," said Milan Godin, an adviser for Belgium to the EU's Working Party on Dual-Use Goods. Belgium doesn't appear to have implemented its own export restrictions yet, but Godin said that quantum computers are a dual-use technology due to their potential to crack commercial or government encryption, as well as the possibility that their speed will eventually allow militaries to make faster and better plans, including in relation to nuclear missile strikes.

A spokesperson for the German Federal Office for Economic Affairs and Export Control confirmed that quantum computer export controls would be the result of negotiations under the Wassenaar Arrangement, adding "these negotiations are confidential, unfortunately we cannot share any details or information about the considerations of this control".

Christopher Monroe, who co-founded quantum computer company IonQ, says people in the industry have noticed the identical bans. "I have no idea who determined the logic behind these numbers," he says, but it may have something to do with the threshold for simulating a quantum computer on an ordinary computer. This becomes exponentially harder as the number of qubits rises, so Monroe believes that the rationale behind the ban could be to restrict quantum computers that are now too advanced to be simulated, even though such devices have no practical applications.

"The fallacy there is that just because you cannot simulate what the quantum computer is doing doesn't make it useful. And by severely limiting research to progress in this grey area, it will surely stifle innovation," he says. ▮

Archaeology

Blue sheep and snow leopards were on the menu for ancient human group

Michael Marshall

ANCIENT humans known as Denisovans hunted a wide range of animals on the Tibetan plateau, including blue sheep, yaks and snow leopards. This varied diet enabled them to thrive in the high-altitude region for tens of thousands of years before the arrival of modern humans.

"Denisovans were behaviourally quite flexible," says Frido Welker at the University of Copenhagen in Denmark. "They're able to really adapt to the local environment and the species that are present there."

The Denisovans are one of the most mysterious groups of hominins with which we once shared the planet. They were first described in 2010, based on DNA extracted from a fragment of finger bone found in Denisova cave in the Altai mountains, Russia. It was the first time a hominin group had been identified solely based on DNA.

It is likely that Denisovans were once widespread in southern Asia because many people in southern Asia and South-East Asia today carry Denisovan DNA, indicating that Denisovans interbred with *Homo sapiens* tens of thousands of years ago. However, Denisova cave has only yielded teeth and other fragments. As a result, we don't know much about what Denisovans looked like.

REALITYIMAGES/SHUTTERSTOCK

Himalayan blue sheep were among the animals hunted by Denisovans

In 2019, researchers including Welker described a jawbone from Baishiya Karst cave in Xiahe in the north-east Tibetan plateau dated to 160,000 years ago. Protein from one of the teeth was identified as Denisovan.

The following year, another group found Denisovan DNA in the sediments of the cave. The DNA was variously 100,000, 60,000 and possibly 45,000 years old – implying that Denisovans lived there for over 100,000 years.

The Tibetan plateau is 4000 metres above sea level. The air is thin and it is cold and dry, making it a challenging place to live. To find out how the Denisovans survived for so long, Welker and his colleagues studied the animal bones from Baishiya Karst cave. By looking at the shapes of the bones and extracting telltale proteins, they identified 2005 out of 2567 bones or bone fragments.

The most numerous animals were blue sheep (*Pseudois nayaur*), or bharal. They and other sheep and goat relatives "make up around half of the assemblage", says Welker. Other medium-sized plant-eaters present included wild yak, Tibetan gazelles and red deer. There were also small animals like groove-toothed flying squirrels and porcupines. What's more, there were some large carnivores, including spotted hyenas, wolves and snow leopards, plus some birds such as golden eagles (*Nature*, doi.org/m6mt).

Most of the bones seem to have been brought in by Denisovans:

"Denisovans were behaviourally quite flexible – able to adapt to the local environment"

19 per cent had clear evidence of this, such as cut marks made by stone tools, and less than 1 per cent showed signs – such as tooth marks – of being carried in by rodents or carnivores.

"This would be the second site where we can be absolutely certain that there are Denisovans present and that the associated assemblages specifically represent their behaviours," says Samantha Brown at the University of Tübingen in Germany. ▮

Climate change

Best way to keep a city cool is to paint the roofs white

PAINTING rooftops white or covering them with a reflective coating is the most effective method of keeping the air temperature down in a city like London during a heatwave. These "cool roofs" should perform better than solar panels, green roofs or adding more trees at ground level.

Oscar Brousse at University College London and his colleagues ran climate simulations to see how London's temperature during the two hottest days of summer in 2018 would have changed if the city had made widespread use of cooling measures, from cool roofs to air conditioning, along with solar panels, which have a cooling effect. Temperatures that summer peaked at 35.6°C (96.1°F).

Cool roofs outperformed all other interventions, the team found, lowering average outdoor temperatures in the city over the two-day period by 1.2°C, and by as much as 2°C in certain locations. By comparison, additional tree cover only curbed air temperatures by about 0.3°C, while solar panels cut them by 0.5°C (*Geophysical Research Letters*, doi.org/m6mv).

The study also found that widespread use of air conditioning might keep internal temperatures cool, but would boost outdoor air temperatures by up to 1°C in parts of central London. "For London, what worked the most for reducing outdoor temperatures at a pedestrian level was the cool roofs," says Brousse.

GRANT ROONEY PREMIUM/ALAMY

If more of London's roofs were white, heatwaves there wouldn't get so hot

Although the study uses only two days of data for the simulations, Brousse says it is broadly in line with similar published research.

Installing reflective coatings or lightening roof surfaces across London would be a relatively easy and low-cost climate adaptation, he says. "I see barely any reason not to start doing it widely."

There are reasons beyond cooling to deploy other technologies too, though, he says. Trees and green roofs can boost biodiversity and resident well-being, for example, while solar panels provide clean power. ▮

Madeleine Cuff

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Comment

A bit of outside help

Grief has a profound effect on our bodies. Taking it into nature offers better healing in the long term than shutting it away, says **Ruth Allen**

IF YOU haven't experienced a significant loss in your life, then you are one of the lucky ones. If you have – be it a spouse, child or close friend – then you probably already know how it can feel like losing your mind. Which, in some ways, you are.

In her extensive grief research, Mary-Frances O'Connor explains that when we experience a profound loss, our brains have to begin a lengthy process of rewiring all of the pathways and predictions they made based on a loved one's presence, gradually switching over to an understanding of their absence. It can take years for our bodies to make sense of loss as we navigate continual yearning while adapting to a new way of life.

And it isn't just our brain chemistry turned upside down, but our whole bodies too. Research shows that grief increases our heart rate and blood pressure, makes us more prone to heart attacks and raises the risk for cardiovascular disease, infections, inflammation, cancer and chronic diseases like diabetes. Closeness to our loved ones is protective against all sorts of external stresses in everyday life, but when they are gone, we are more likely to feel exposed to what life throws at us, causing a flood of stress hormones that affect our cardiovascular and immune systems.

This should encourage us to give our grieving the space and support it deserves, rather than shutting it away and avoiding it. A 2022 report by the UK Commission on Bereavement highlighted that we need to do a lot better in how we support grief at home, in schools and in the workplace. Too often, we don't know how to talk about grief, how to support the bodies of those grieving or how to show compassion for ourselves and each other. In many ways, we are still wed to the idea that grief progresses in stages towards an endpoint, as psychiatrist Elisabeth Kübler-Ross famously formulated. However, the idea that we might pass through steps in a linear fashion only exerts undue pressure to "move on".

ELAINE KNOX

In reality, grief moves in cycles and is never "done", which is why, as an outdoor psychotherapist, I am passionate about getting people outside to tend to their grief in a non-judgemental environment where the circularity of life and death, joy and sadness, is the norm.

In the shifting landscape of grief, what we need is solid ground on which to learn how to function anew without intrusion from the demands of our busy, indoor lives. Time outside promotes mindfulness, allowing the griever to anchor themselves in the soothing senses of nature. It offers solitude and space for contemplation, a soundscape that is ambient and restorative, something beautiful to focus on other than our loss. Getting outside often dials down the feelings of rumination and despair that grief ramps up, even if just for a short while.

There isn't yet much research on nature-based support for grieving people specifically, but there is an abundance of research on the physiological benefits of connecting with nature that can usefully counter many of the impacts of grief. Time outside lowers our blood pressure and the production of stress hormones, reduces inflammation and decreases the risk of heart disease. So it is an intuitive pairing to take our grieving bodies outside.

Grief isn't pathological and doesn't often require medication, but it is something we all need support for in the long term and can learn to be a better companion for others in. Bereavement is so ubiquitous that it is vital we learn how to tend to it using the resources we have around us. It is crucial that our green sanctuary spaces and green social projects are invested in, for their own sake, but also for this most human experience that we will all face, one way or another.

Ruth Allen is the author of *Weathering: How the Earth's deep wisdom can help us endure life's storms*

This changes everything

Flying into the future

Tired of today's instability, I asked some experts what Earth will look like in 25 years, says **Annalee Newitz**. Get ready for green mining, soft cities and robo-taxis

Annalee Newitz is a science journalist and author. Their latest book is *Stories Are Weapons: Psychological warfare and the American mind.* They are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
Premee Mohamed's novella We Speak Through the Mountain, *a far-future tale of cities under domes.*

What I'm watching
The new season of punk feminist dramedy We Are Lady Parts.

What I'm working on
Getting rid of my teetering pile of ancient laptops, phones and tablets.

This column appears monthly. Up next week: Rowan Hooper

THINGS are just a wee bit unstable right now – environmentally and politically – so I decided to call up some experts and find out what will be happening on Earth in 25 years. Perhaps sounding a little desperate, I asked each of them what I would see if I flew over our future planet, peering down on humanity like a sentient satellite. Would it be a blasted wasteland?

Their answers were a lot weirder than I expected.

Despite everything, most nations are transitioning at least partly to sustainable energy, using periodic sources like wind, solar and waves. That, according to science fiction author and reservoir engineer Wole Talabi, means we are going to be doing more mining for rare earth metals to make batteries. But those mines won't look like deep cuts and holes in Earth's surface. Talabi, who works on liquid resource extraction in Australia, says future mines might be almost invisible from the air.

"Instead of bringing up earth to extract what's inside, we could extract it without blasting or digging at all," he says. "You would drill a hole or several holes into target rock, inject chemicals, concentrate [the minerals] in situ and bring up what you need." These "in situ" mines would have a small footprint and could even be surrounded by trees to make them blend into their environment.

He imagines mining operations that essentially clean up after themselves in a process he calls "coupling", or "linking whatever energy-intensive process you're doing to a carbon drawdown process and doing them almost at the same time". One company, Arca Climate, is already doing this in Australia. The firm binds carbon dioxide to rocks pulled up during mining in a process called carbon mineralisation – it is a natural phenomenon, but usually takes thousands of years.

Talabi says a similar coupling technique could utterly transform offshore gas platforms. Instead of gray slabs of steel, the platforms might be covered in glittering solar panels, surrounded by fields of green algae that feed on CO_2. Excess CO_2 could also be reinjected into the ground, says Talabi. From the air, we might see two pipelines running between the coastal industrial complex and the platform – one carrying gas to land, the other carrying CO_2 to an injection site deep beneath the seafloor, where it would dissolve and mineralise over time.

"Imagine a city surrounded by huge batteries that look like hills, gushing with sparkling streams"

The idea of gray infrastructure going green was also appealing to Deb Chachra, a professor of materials science at Olin College in Massachusetts and the author of *How Infrastructure Works*. Chachra sees a future where concrete is abandoned because cities need to absorb water runoff. City blocks will become porous, edged by lawns and bioswales, open patches of soil and plants that will capture water from floods, which will come more often due to climate change.

This soft, green infrastructure could help with aquifer recharging too: "It would make sense for Mexico City to do that to regain water," says Chachra. "You might see Mexico City is weirdly green because they're managing water the same way they did when it was Tenochtitlan. The axolotls will come back too."

Chachra says we might not need conventional batteries at all: "I can imagine seeing grid-scale infrastructure that's a ziggurat of concrete blocks next to the solar plant. You're stacking the blocks and unstacking them as potential energy." She points out that the container ship port in Kodiak, Alaska, has a flywheel that stores the energy from putting containers down and discharges that energy to stack them back up. Pumped storage hydropower plants are another example of storage that banks gravitational potential energy in stacked water reservoirs.

Imagine a city surrounded by huge batteries that look like hills gushing with sparkling streams. Its ports are connected to offshore drilling platforms that are piping in oil for power and algae for food, while also removing excess CO_2 to inject deep below the ocean floor.

But how will people get around this future city? Will we have flying cars? To find out, I talked to Jinhua Zhao, professor of cities and transportation at the Massachusetts Institute of Technology. He is dubious about flying cars, but does think our ways of getting around would change dramatically. Your mode of transit would depend on the density of the area you were in. If you looked at Zhao's ideal city of the future from above, downtown would be full of bicycles, scooters and pedestrians. Robo-taxis would help people get around less dense residential areas, and regional corridors would have frequent, high-speed trains, travelling at 480 kilometres per hour, he says. Travel would be utterly transformed.

I'm ready for squishy cities and green mining and robo-taxis that drop me off at the bikeshare. I'm not looking for utopia. Just something better than this. ▮

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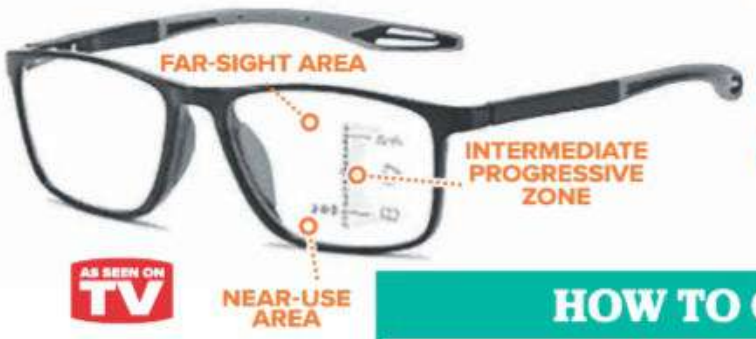

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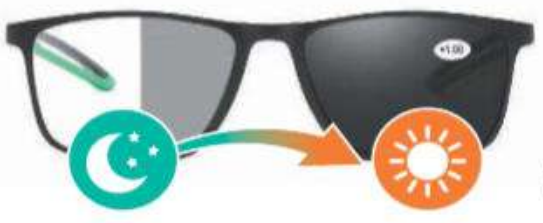

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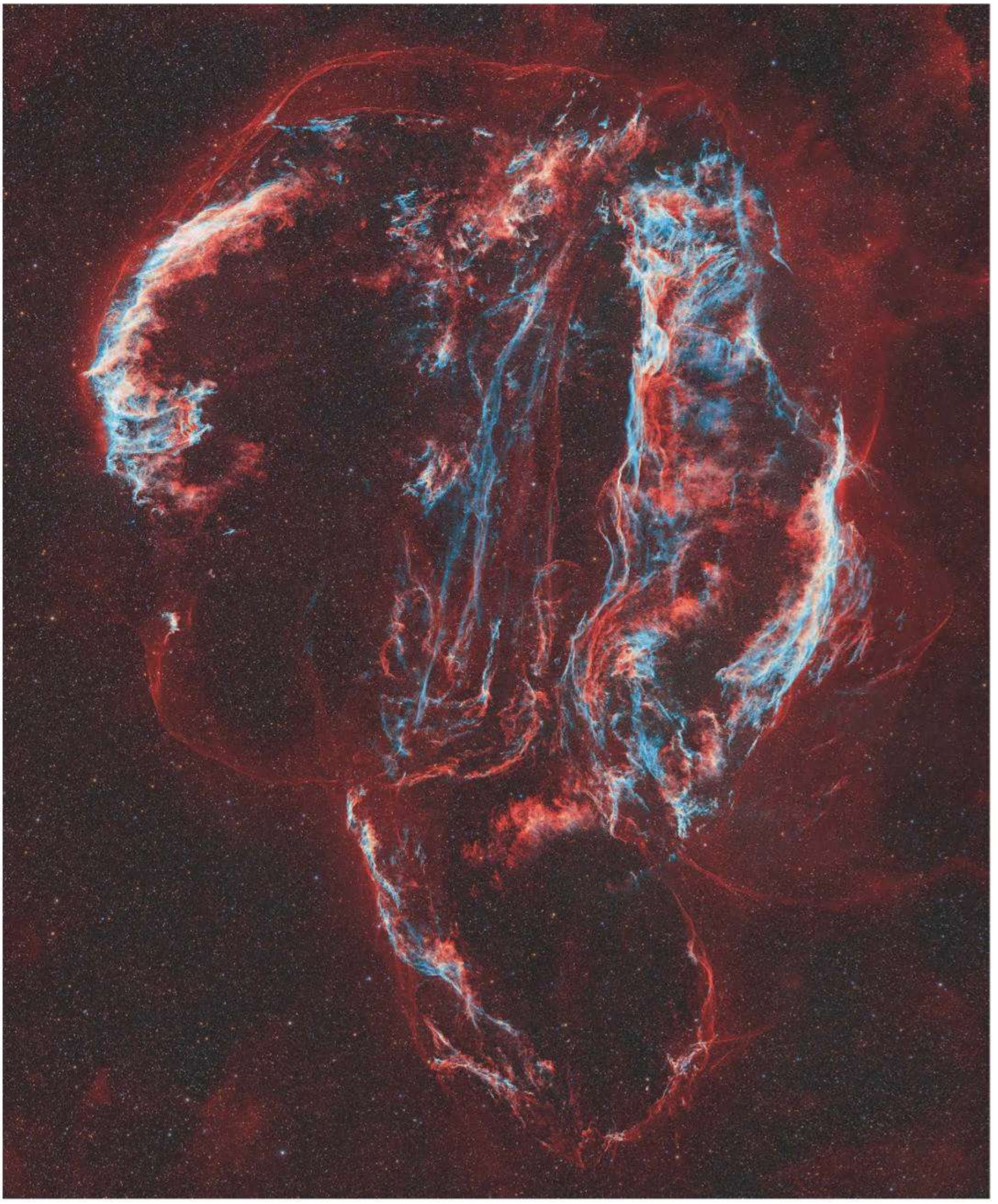

L: YANN SAINTY; R: GESHUANG CHEN

Star turns

ASTRONOMY Photographer of the Year, the annual photo competition showcasing all things space, is back for its 16th run.

More than 3500 images were submitted for the award. Among the 30 to make the shortlist is *The Scream of a Dying Star* (far left), taken by Yann Sainty. The "star" in question is actually what remains of a supernova – when a star dies and explodes in a tremendous display of light and energy. This one occurred around 10,000 years ago.

Sainty exposed rarely seen details of this glowing remnant, called the Cygnus Loop, by capitalising on a clear sky in the Atlas mountains in Morocco, combined with a long exposure time. The image's name is a nod to the famous painting *The Scream* by Edvard Munch, though it also symbolises the "scream" that echoes through space after a star dies, according to Sainty.

At near left is a dazzling shot of the sun's corona (its outermost layer of atmosphere) above the Himalayas, captured by Geshuang Chen near the Tibetan city of Shigatse. Usually hidden by the brightness of the sun's surface, here its corona can be glimpsed thanks to the thin, blanketing clouds that diffract sunlight as it passes through, resulting in this vibrant array of iridescent colours. Chen has called the image *The Palette of the Himalayas*.

The winners of the competition, which is run by the Royal Observatory in London, will be announced on 12 September. The winning images will be displayed in an exhibition at the National Maritime Museum in London from 14 September, alongside a selection of shortlisted images.

Gege Li

Editor's pick

Brighten clouds to modify climate, but do it carefully

29 June, p 11

From Gillian Graham, Peterborough, Cambridgeshire, UK

You report that spraying salt water into the atmosphere over the Pacific to brighten clouds for nine months a year for 30 years to save California from extreme heat could eventually cause dire temperature increases in Europe as a side effect.

However, other studies are more hopeful about such geoengineering. Some suggest small amounts of spraying, moved seasonally and controlled by an international team to safeguard the interests of all countries. Another found using much lower spray rates would give up to 20 per cent more rain in north-west Africa and Pakistan, and maybe 10 per cent more in the Sahara, South Africa, Saudi Arabia, India, Australia and Central America. These models made small changes in parameters to get great effects, which shows we need trials where we can make adjustments as we go.

For cosmic significance, size doesn't really matter

29 June, p 36

From Andrew Whiteley, Consett, County Durham, UK

The idea of our cosmic insignificance is a matter of emotion rather than reason. We all feel it, but it does, after all, involve equating physical size with significance. This is absurd, as we don't say an elephant is more significant than a human, or a mountain than an elephant. What happens is that, when a certain point of absolute size is reached, our imaginations kick in and we turn mere statistics and quantities into a quality: the awesome.

The cosmos is overpoweringly great only because we are here to see it that way – in a sense, it owes its greatness to us. In this and other ways, the vastness of the cosmos points to us rather than away from us. The cosmos is a great wonder, but a still greater and more central wonder is the human mind and spirit.

This is how the universe has become conscious

29 June, p 30

From Ron Barnes, King's Lynn, Norfolk, UK

When it comes to our "cosmic perspective", there is one aspect of our existence that I find deeply significant. We are composed of matter and energy that has become capable of thinking about and describing matter and energy. Thus, through us and any other technologically advanced beings that may exist, matter/energy – and, by extension, the universe – has become consciously aware of itself. I find this very profound.

The young are becoming consumeristic sheep

22 June, p 31

From John Koster, Santa Cruz, California, US

The article "Digital damage?" misses the real danger to children from screen time – the extremely sophisticated marketing that sucks them into ruthless games that have no socially redeeming value. They are being purposely led deeper and deeper into a highly cloistered digital environment and away from being able to develop discrimination regarding how they spend the limited time we have on this beautiful Earth.

In order to be healthy, we need to develop a traditional relationship with nature and read the printed word, such as books. Unless parents and society take a stand on this, the end result is certainly increasingly larger new generations of easily manipulated consumeristic sheep.

Surely physical reality won't tolerate infinity

15 June, p 32

From Frank Read, Orleton, Herefordshire, UK

You write about the singularity, the "infinitesimal point of infinite density" within a black hole. The concepts of infinitesimally small and infinitely large are extremely powerful in pure mathematics. But is their use acceptable in trying to model the physical universe?

At the centre of a black hole, the wave-like particles are fighting against the gravitational forces that are trying to compress them to a point. And if there really are such singularities, then by definition they can't be modelled and can't carry detailed information. Surely I am not the only person to question the use of these extreme mathematical concepts in trying to understand our physical universe.

Beautiful image also highlights ugly truth

15 June, p 26

From Paul Broady, Christchurch, New Zealand

What a magnificent photograph of the Milky Way seemingly emerging from the summit of Aoraki/Mount Cook in Aotearoa/New Zealand. In it, our galaxy also seems to be looking down on the rapidly retreating terminus of the Hooker glacier and the equally rapidly expanding Hooker Lake. By 2016, this lake had lengthened from nothing to 2.5 kilometres. It has continued to fill up the valley it occupies and will probably stop when it stretches for 4 kilometres. The base of the glacier will then be above the lake surface.

I wonder whether there are civilisations up there wondering why we have so far completely failed to end global warming.

Mixing it up is great for runners too

22 June, p 8

From Andy Bebington, London, UK

You outline research showing how varying stride length while walking helps burn more calories. However, it does more than that. It enhances muscle tone and overall fitness. This is the idea behind fartlek, a training method for runners. Practitioners vary their pace (and thus their stride length) while running through woodland or open country, switching from a gentle jog to a race-pace run to an all-out sprint and repeat.

Adherents develop muscles better suited for distance racing. You burn more calories and also enhance your racing potential.

On the drive to tackle the obesity epidemic

29 June, p 12

From Alex McDowell, London, UK

You raise the idea of paying people to lose weight. Use of financial incentives isn't new. American football player William "The Refrigerator" Perry had a clause in his contract with the Chicago Bears stating he would be penalised if his body weight went above a certain level.

From John Kitchen, Kettering, Northamptonshire, UK

When it comes to obesity, some people claim healthy food costs more. This is false. I cook all my food, mostly vegan, and it costs just a fraction of what most people spend on their unhealthy food.

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For the record

There is one vagus nerve on each side of the human neck (29 June, p 19).

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Think like a teenager

An eye-opening new book lifts the lid on the surprisingly rational strategies behind the risky behaviours of adolescents, finds **Catherine de Lange**

Book

Coming of Age
Lucy Foulkes
Bodley Head (UK); Vintage Digital (US)

VIRGINIA WOODS-JACK/MILLENNIUM IMAGES, UK

Teenage cliques can offer protection – or enforce exclusion

IN THE teen movie *Mean Girls*, protagonist Cady Heron arrives at a US high school having grown up in Africa. Baffled by her peers and the social hierarchies of school, she approaches things as her zoologist parents would – documenting the people around her as if they were animals living on the savannah.

In her new book, *Coming of Age: How adolescence shapes us*, psychologist Lucy Foulkes takes a similar approach to decoding the rulebook of adolescence, coolly describing the teen tribe from the outside, even though she has spent years working with them.

The result is a refreshingly clear-eyed description of the forces that shape adolescent behaviours and emotions. Teens are often viewed through a lens of judgement or morality, their actions reduced to the products of hormones or immature minds. But you will find none of that here.

Each short chapter is cleverly punctuated by often-moving interviews about people's adolescent years. Take 14-year-old Emma, who got pregnant and discovered what it was like to have a baby at school. In a terrible turn of events, the baby died, so she had to deal with grief, too. The stories add humanity to the research and complement Foulkes's succinct and objective writing style.

She starts by describing the microcosm of secondary or high school, where most of our teenage adventures play out. As the writers of teen movies know, the rules governing this environment are surprisingly universal. Research backs this up: high school is governed by a strong hierarchical structure with a few high-status pupils at the top. Students quickly organise into cliques, which offer social protection, although attempts to leave such groups can come at a high individual cost.

> **"Teenagers have much to gain from risk-taking – and more to lose by avoiding those behaviours"**

This pecking order, and our place in it, can play a big role in shaping self-identity, says Foulkes, influencing us for years to come. Though we tend to view teens as rebellious, much of their behaviour is actually highly conservative. From wearing the right clothes to the people you should fancy, successfully following the rigid rules set by more popular kids can make the difference between an easy life and social ostracism.

The need to fit in is also the source of many other behaviours, such as risk-taking. We know teens take all sorts of risks – from drugs to drinking, driving too fast and unprotected sex – and overall do so more often than children or adults.

But while we often see this as irresponsible, Foulkes paints a different picture. We may, for instance, think that teenagers underestimate the size of the risks they take, but evidence shows that, if anything, they overestimate the potential negative outcomes of many risky behaviours. Teenagers, she writes, have much to gain from risk-taking – and much more to lose by playing it safe.

Taking risks helps them develop independence while still fitting in with peers; refusing to engage in such behaviours would mean taking a huge social risk. Framed this way, doing dangerous things other teens do is, in fact, a risk-averse behaviour. We see the rationality behind it.

The desire to fit in also helps explain bullying. In one of her most powerful chapters, Foulkes writes that "just as the victim is seen as having broken certain norms, the whole peer group must then follow a new norm: agree with the bully and ostracise the victim, lest you end up a target".

Foulkes delivers a positive message, too, by highlighting research into how to prevent bullying, and the fact that some students (those who are highly empathetic with a strong belief in themselves as change-makers) can be instrumental in stopping it.

Chapters like these, as well as ones on sex, love and grief, can help parents and teachers understand teenagers free from judgements and stereotypes, with renewed respect and armed with advice on setting boundaries.

This book will also send you down memory lane, and is likely to give you a fresh perspective on the adolescent events that left an indelible mark on your own identity, however long ago that was. It is an eye-opening read for anyone who knows a teenager, or who has been one. ▮

Failure to launch

From flying cars to smart robots, why do many promised technologies remain out of reach, asks **Matthew Sparkes**

Book

The Long History of the Future
Nicole Kobie
Bloomsbury Sigma
(UK, on sale now; US, 24 September)

A HANDFUL of technologies teeter on the cusp of release but never arrive. Take driverless (or even flying) cars, superintelligent machines and human-like robots that free us from the drudgery of everyday chores. What stops them leaving the minds of inventors and entering our homes?

That is what Nicole Kobie asks in *The Long History of the Future: Why tomorrow's technology still isn't here*. While the answer can simply be because a given problem is very hard, she writes, it may also be that the proposed solution isn't very sensible and isn't at all the best way to solve the underlying issue.

Yes, flying cars would soar past congested traffic. But safe bicycle lanes would dissolve those queues. Yes, an underground network, or hyperloop, of autonomous vehicles would whisk people from one end of a city to the other at high speeds. But so do some trains.

Flying cars have long been part of our imagined future – but that is where they may remain

Kobie points out that many of these technological promises have longer and more complex histories than we realise. For instance, the term "artificial intelligence" was first coined in the 1950s, and the first "driverless" car was approved for sale in the US in 1956.

And robotics can be traced back to Leonardo da Vinci's "mechanical knight" in 1495, a fairly humble machine that could stand, sit and move its arms, but one that was a huge achievement for the time. So why, over 500 years later, are we still folding laundry ourselves?

As one academic tells Kobie in the book, a driverless car that works 95 per cent of the time is nowhere near good enough – you need 99.999 per cent. And every decimal place of reliability takes another five to 10 years to achieve. The failure of robots, driverless cars and other devices to materialise in a useful form isn't through lack of effort or investment, it is that they are only useful once they are useful, and that is a very hard problem to solve.

Kobie does a wonderful job of teasing out key moments and concepts, weaving together a compelling history of long-awaited technologies. It is easier to understand why, say, driverless cars haven't arrived once you know researchers have been working on them ever since cars were invented.

The string of failed attempts, dead-ends and premature launches are as entertaining as they are cautionary. One such example was the 1947 ConvAirCar, which could work as both car and plane, to some extent. On a test flight, the pilot crashed when he looked at the wrong dashboard – there were two, one for the plane, one for the car. He didn't notice he had run out of fuel.

Another problem Kobie sees with technological progress is the cost, often needing the sort of talent and cash available in Silicon Valley. This tends to place the power of deciding what gets built in the hands of a few powerful white men – people who may be insulated from the everyday problems that really need solving.

But for all Kobie's perfectly valid points about the slow growth of technology in some areas and the misguided efforts of some really smart people with enviable funding, it is worth pointing out that science still throws up unexpected delights.

Who could have foreseen just five years ago that we could use AI to predict the structure of nearly every protein known to science? Or that "transformer" models (despite their faults) would create coherent essays, photorealistic images and even whole songs?

And there are other long-predicted technologies that now seem genuinely close to roll-out. Within a few years, we could have useful quantum computers, and fusion power is really edging closer.

Kobie is right that some problems are far bigger and thornier than we thought, but we should never forget the power of the unexpected along the enchanted route to progress.

SHUTTERSTOCK/DESIGN PROJECTS

New Scientist *recommends*

Alison Flood
Culture editor
London

I have been reading a vast amount of popular science in the past month or so, nearly all brilliant, of course – what else would you expect *New Scientist*'s culture editor to say? But it has also

been wonderful to take myself out of the real world with a slice of sci-fi from Martha Wells, **All Systems Red** (pictured).

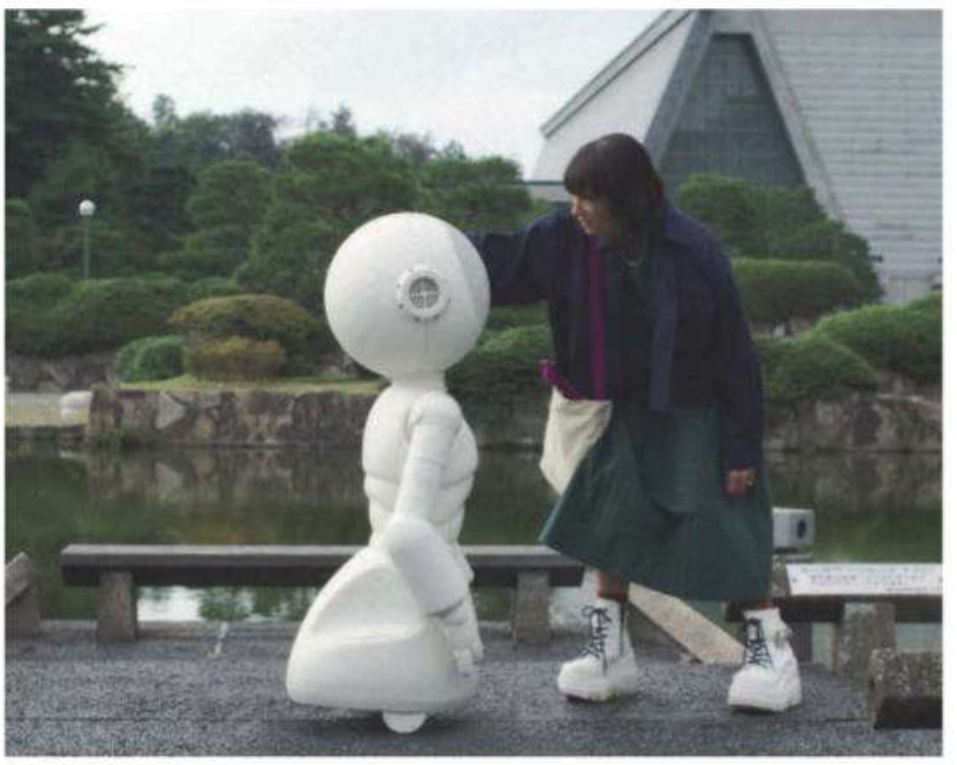
The first in Wells's *The Murderbot Diaries* series, it introduces us to Murderbot, a part-robot, part-organic security unit that has overridden its programming and prefers to spend its time catching up on TV, while feeling obliged to protect the puny humans in its care. Murderbot's tone is brilliantly sardonic and this was a real escapist read for me. We are reading it in the New Scientist Book Club – do come and join us!

I have also been escaping to somewhere less pleasant with the **Fallout** TV series, which is set after a nuclear war and was highly recommended by our TV columnist, Bethan Ackerley. As a huge *Twin Peaks* fan, it is always damn fine to see Kyle MacLachlan in action.

The TV column

Raw reality In Apple TV+'s *Sunny*, Japan-based expat Suzie is grieving the loss of her husband and son in a plane crash as a cute housebot mysteriously arrives. It is out to befriend her – and to prime us to love the show, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on X @inkerley



APPLE TV+

Suzie (Rashida Jones) and robot Sunny investigate her husband's secret past

BIG eyes and heads, small mouths and noses – these are all characteristics that prime us to love baby animals. The same is true of Sunny, the eponymous star of a new comedy-drama on Apple TV+. The moment I saw her, I knew I loved her – from her wobbling, outsized head down to her gently whirring tyres.

Sunny (voiced by Joanna Sotomura in this 10-part show) belongs to Suzie (Rashida Jones), a US expat living in Kyoto, Japan. Her husband, Masa (Hidetoshi Nishijima), and their son, Zen, have recently disappeared in a plane crash. While she grieves, a mysterious stranger sends her Sunny, a household robot that, to Suzie's surprise, was designed by Masa. Suzie and Sunny eventually team up to uncover Masa's secret life and are pulled deeper into a dangerous underworld.

I have long wished for a series that might match the talents of *Sunny*'s human star, Jones, who I enjoyed as Ann Perkins in the sitcom *Parks and Recreation*. Her character was neglected in later seasons and then written out. Many of Jones's recent projects, including Apple TV+'s *Silo,* offered her little opportunity to shine. So I am primed to look favourably on any show that uses her properly.

But Jones is terrific as Suzie, a curmudgeon's curmudgeon, who has somehow stumbled into a loving family unit. Her acerbic personality isn't a side effect of grief – she has been off-putting and unpleasant for the best part of a decade, not least to her mother-in-law, Noriko (Judy Ongg). Pair that with Sunny's cheery disposition and you have a classic buddy-cop dynamic. But can Suzie trust her new pal's programming?

"The series seems to be aiming for a tone close to that of hit drama *Killing Eve*: tart, stylish, with offbeat humour"

Sunny is, quite explicitly, a show about loneliness. Suzie has no friends to help her through her grief and is isolated as a foreigner in Japan. Masa, we discover, spent three years in *hikikomori*, a condition first identified in Japan where people withdraw from society. So it is heartwarming to see Suzie grow attached to Sunny.

Not that it is hard to find the robot loveable. Sunny's pleasingly *kawaii* (cute) aesthetic is one of many gorgeous elements in the show: its version of a near-future Kyoto will be heaven for viewers with an eye for design or fashion. Lucy Tcherniak's direction has a freewheeling quality that bursts with character and there's an outstanding soundtrack of 1960s Japanese hits. The series seems to be aiming for a tone close to that of the UK hit drama *Killing Eve*: tart, stylish, with lots of offbeat humour.

But despite the promising parts, I found myself caught between what the show is and what it could be. We catch tantalising glimpses of deeper questions, when, for example, the show points out the errors we make in assigning value to the wrong things and the wrong people. We get attached to clothes we have outgrown and grieve for home appliances. Worse, we fall in love with difficult people and retreat from those who wish us well. These are errors in categorisation, glitches in our programming.

When *Sunny* asks us why Suzie pushes away her friends or picks a homebot over her family, it hits on something raw and unsolvable in us all. Yet it largely avoids that complexity in favour of simplistic takes on tech and loneliness, a lot of filler and a sprawling conspiracy with actors who lack the gravitas to pull it off. By the series' messy conclusion, I had fallen out of love with the story Sunny had primed me to adore. ▮

TV

Sunny

Creator: Katie Robbins

Apple TV+

Bethan also recommends...

TV

Killing Eve

Based on the novels by Luke Jennings

BBC iPlayer (UK); AMC+ (US)

The first season of this thriller, written by Phoebe Waller-Bridge, was practically perfect. Less so the other three, but the story of assassin Villanelle and spy Eve Polastri is intoxicating.

Giri/Haji

Creator: Joe Barton

Netflix

A Japanese police officer comes to London to find his brother, a hitman for the yakuza, long thought dead. This underworld thriller is bold and impressionistic.

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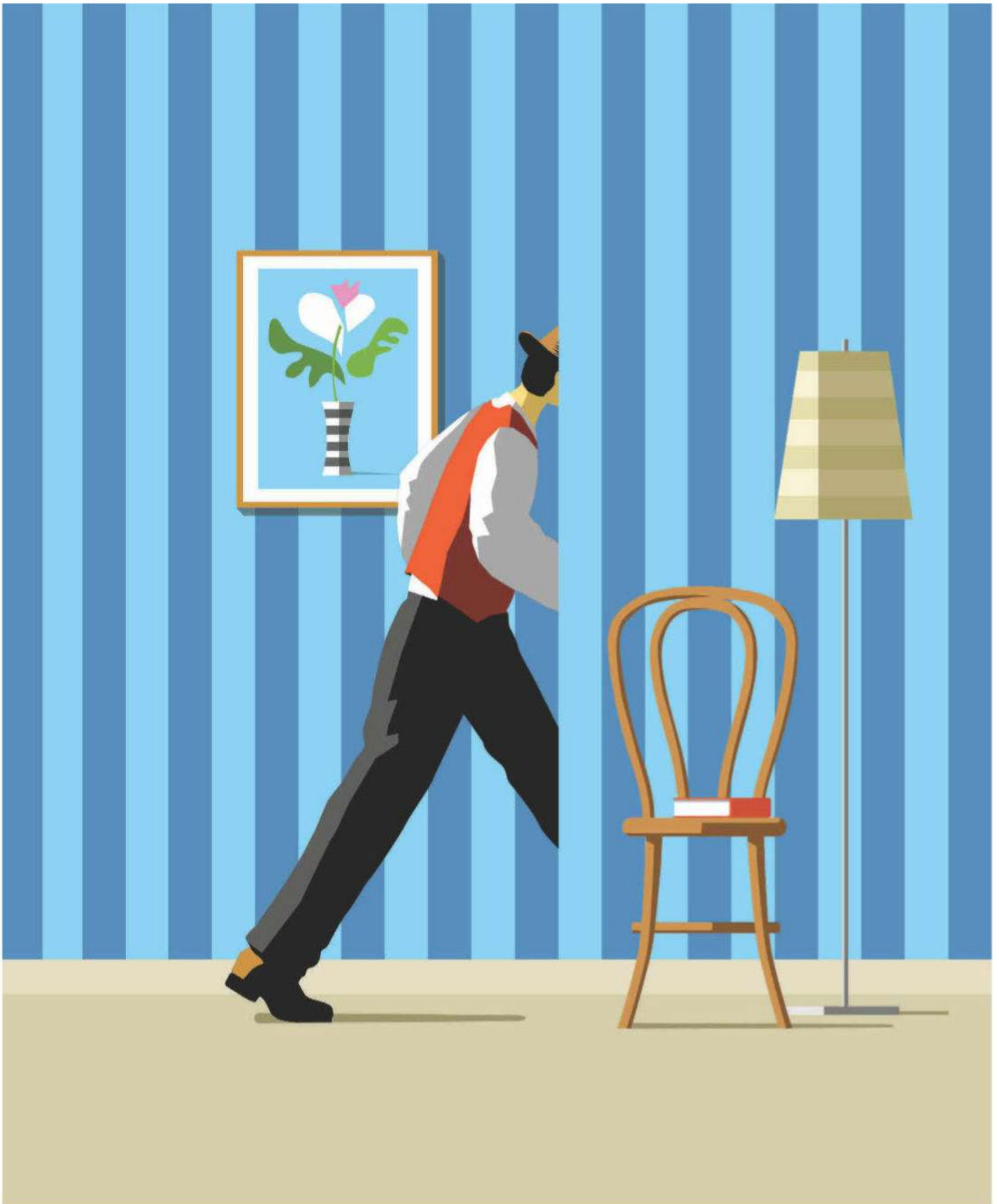

CRAIG FRAZIER

The spaces in between

Proof of extra dimensions has eluded physicists for decades. Now that looks set to change, and a newly proposed "dark dimension" could be within their sights, finds **Chen Ly**

WE TEND not to dwell on the fact that we exist in three dimensions. Forwards-back, left-right, up-down; these are the axes on which we navigate the world. When we try to imagine something else, it typically conjures images from the wildest science fiction – of portals in the fabric of space-time and parallel worlds.

Yet serious physicists have long been spellbound by the prospect of extra dimensions. For all their intangibility, they promise to resolve several big questions about the deepest workings of the universe. Besides, they can't be ruled out simply because they are difficult to imagine and even harder to observe. "There's no reason why it has to be three," says Georges Obied at the University of Oxford. "It could have been two; it could have been four or 10."

Still, there comes a point when any self-respecting physicist wants hard evidence. Which is why it is so exciting that, over the past few years, researchers have developed a handful of techniques that could finally snare proof of extra dimensions. We might yet spot gravity leaking into them, for instance. We may see their subtle imprint on black holes or find their traces in particle accelerators.

But now, in an unexpected twist, Obied and others are making the case for an extra dimension that is radically unlike any we have concocted previously. This "dark dimension" would conceal particles from the dawn of time that could solve the mystery of dark matter, whose gravitational pull is thought to have shaped the cosmos. Crucially, it should also be relatively easy to spot – and experiments are already underway that could reveal it or rule it out.

It isn't difficult to define a dimension. "It basically refers to the directions you can move," says Obied. You can thus think of the spatial dimensions as the x, y and z axes on a line drawing of a cube. Some see time as another dimension, giving us the concept of four-dimensional space-time.

To explain why we find it so hard to think beyond this, physicists often reference the 19th-century novel *Flatland: A romance of many dimensions* by Edwin Abbott. The story's protagonist is a square who lives in a strictly two-dimensional world. One day, the square is visited by a sphere. He is unable to observe the sphere's true form and only sees it in cross-sections, a series of circles of varying diameter. Gradually, the square begins to grapple with the realisation that his smooth world may not be the full extent of reality.

Physicists' fascination with extra dimensions really picked up in the early 20th century. In 1915, Albert Einstein published his general theory of relativity, in which gravity arises from the warping of four-dimensional space-time by massive objects. A few years later, physicist Theodor Kaluza was playing with Einstein's equations and introduced a fifth dimension. At first, there was little expectation behind this. It was more or less a case of adding extra mathematical terms to the equations – a w to go along with x, y and z.

But astonishingly, Kaluza's additions provided a way of accurately representing electromagnetic fields. In other words, this five-dimensional extension of general relativity seemed to elegantly unify two fundamental forces – gravity and electromagnetism – in a single framework. Kaluza's contemporaries went further, speculating that gravity might somehow "leak" into this extra dimension, potentially explaining one of the major mysteries of physics: why gravity is so exceptionally weak compared with the other forces of nature.

In 1926, theoretical physicist Oskar Klein looked at Kaluza's framework again, now from the perspective of newly discovered quantum theory. His analysis suggested that the extra dimension through which electromagnetism worked would have to be inestimably small – far smaller than an atom – with a radius of just 10^{-32} metres. Klein proposed that this diaphanous dimension would exist at every point in space, rolled up like an infinitesimal tape measure.

We now know that the Kaluza-Klein hypothesis, as it has come to be known, isn't a true reflection of reality. Modern physics sees electromagnetism as operating through a quantum field in our familiar space-time. Nonetheless, the idea of invoking extra dimensions to explain away difficulties in physics endured. "Even though we now know that isn't our universe, it did inspire some people to study ideas of higher dimensions from the mid-20th century," says Cumrun Vafa, a theorist at Harvard University.

Ultimately, that led to Vafa's field of study, string theory. It says that everything is made of strings that vibrate in 10 dimensions, at least six of which are tiny and tightly coiled, like those that Klein envisaged. Fundamental particles – electrons, quarks, Higgs bosons – are nodes of the string that intersect the dimensions with which we are familiar.

That may sound far out. But physicists find it compelling partly because the maths of string theory is so elegant. "We can very ›

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easily extend our mathematics to more dimensions, and indeed, some of mathematics works better or gives kind of the right answer in higher dimensions," says cosmologist Tessa Baker at the University of Portsmouth, UK. String theory has also led to all sorts of insights in other, unrelated fields, which, to some theorists, gives it the ring of truth.

The principle reason why extra dimensions are so fiendishly difficult to detect is their size. "Imagine you're trying to knit something using boxing gloves," says Joseph Conlon at the University of Oxford. "You just cannot possibly feel it because the boxing gloves are big and crude, and the yarn is very fine and small."

There is a workaround. Physicists believe that fundamental particles are generally banned from moving in extra dimensions. "Our objects don't really exist in that extra dimension," says Kris Pardo at the University of Southern California. But there may be exceptions. Extra dimensions are essentially gossamer filaments of space-time, which implies they have a gravitational field. By extension, hypothetical particles called gravitons, thought to carry the force of gravity, ought to be able to traverse these extra dimensions. That raises the possibility of spotting an extra dimension by watching gravity, in the form of gravitons, vanish into it.

We now have the opportunity to do just that, thanks to gravitational waves, or ripples in space-time. These waves are caused by the epic collisions of black holes or neutron stars in the distant cosmos. If we could watch the waves diminish in power as they swish towards us, that would be a sign that gravity is leaking into an extra dimension.

A chance presented itself in 2017, when astronomers spotted the cataclysmic merger of two neutron stars. In this rare case, they saw both the gravitational waves that emanated from it and the explosion of visible light, called a kilonova, it produced. Pardo and his colleagues jumped into action. "We were looking to see how far away the light told us this merger was, compared to the distance the gravitational waves told us it was," says Pardo. If the gravitational waves seemed to come from a much greater distance, that would have been a sign of the gravitational power slipping away.

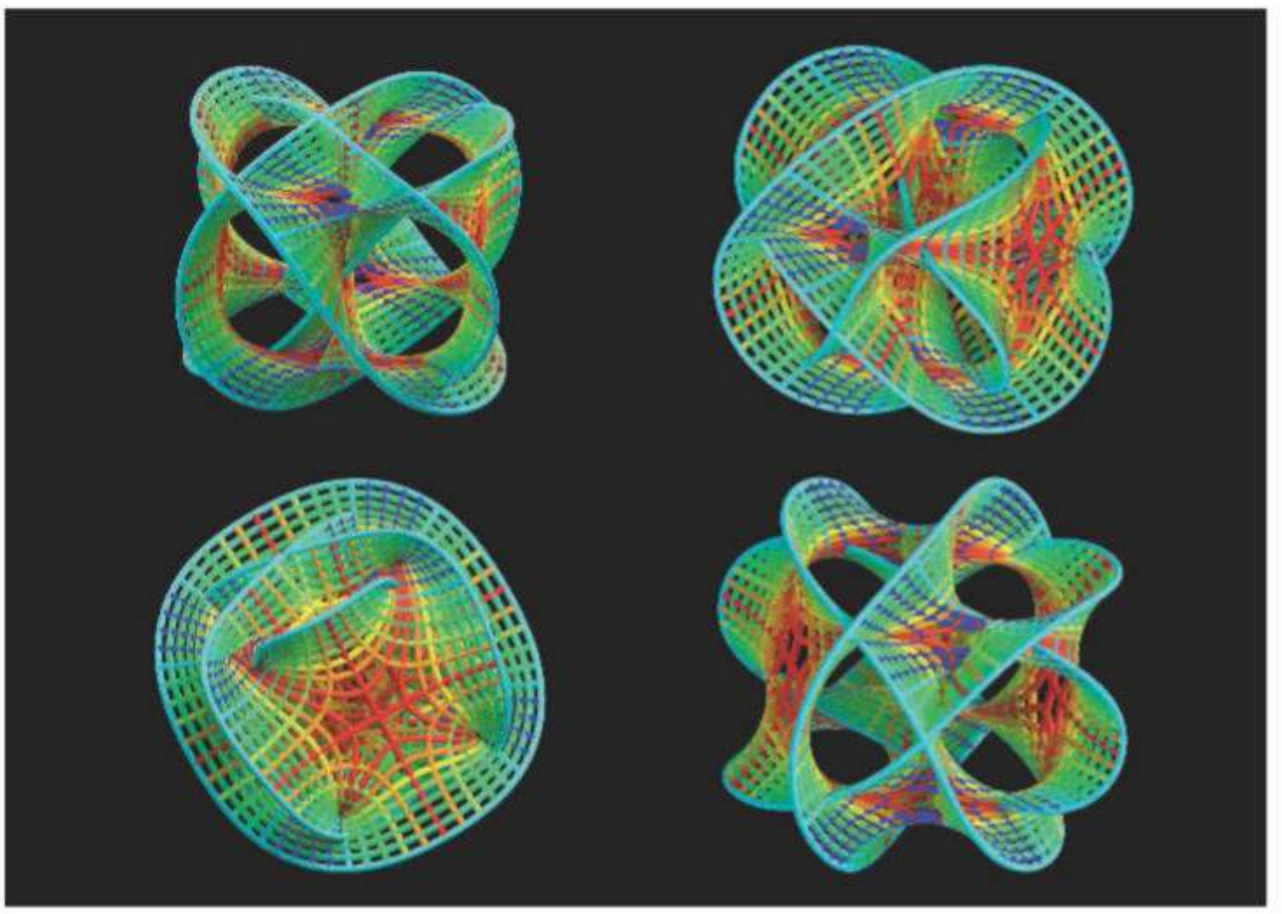
They found no evidence of such an effect, though Pardo says that may just be due to the constraints of our technology. At the moment, we can only detect fairly low frequencies of gravitational waves. Higher frequencies are more likely to be affected by putative extra dimensions because their wavelengths would be a closer match for the size of these dimensions, but we won't see them until we have more advanced detectors. Pardo says the Gravity from the Quantum Entanglement of Space Time (GQuEST) experiment, currently under construction at the California Institute of Technology, may offer us hope.

"The dark dimension would be a micrometre wide – a giant among dimensions"

Extra dimension hunters have other methods at their disposal too, such as looking at the large-scale structure of the universe. The arrangement of galaxies is especially sensitive to the laws of gravity, says Baker. If we tweak our accepted models of how gravity works – by postulating that it escapes into higher dimensions, for example – then the way that galaxies cluster would also change. Baker and others are therefore running simulations of how extra dimensions would affect this pattern. They can then compare their simulated patterns with observations, which are getting more precise and comprehensive all the time. "We're up to billions of galaxies now," says Baker. Any differences, which of course would be slight, could be evidence of higher dimensions.

Perhaps the strangest observational implication of extra dimensions involves the appearance of lookalike particles. An extra dimension is essentially a bonus direction in which a graviton can travel. And some physicists think that other force-carrying particles, like the W and Z bosons, the carriers of the weak nuclear force, could also traverse extra dimensions. It follows that these particles must have momentum in each additional dimension, says Obied. And in our three-dimensional space, that would appear as extra mass. In practice, then, we would expect to see some signature of gravitons or other force-carrying particles with the exact same properties, except two, three or more times their usual mass, depending on the

Extra dimensions would be folded up in extremely complicated geometries



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number of extra dimensions out there.

It must be said that we have never seen a graviton, and if they do exist, they must be extremely light or even massless. But, in principle, gravitons could be produced in particle collisions at the Large Hadron Collider near Geneva and then disappear quickly into extra dimenions. Or we might perhaps spot a particle that looks just like a W boson but 10 times heavier. Physicists have searched for these signs and come up empty.

These lookalike particles would also affect the properties of black holes. When black holes bump into each other or neutron stars, they release energy in the form of gravitational waves – much like during neutron star mergers. Towards the end of this process, the black hole goes through a fleeting stage called ringdown, where – for a fraction of a second – the waves "ring" like a wine glass tapped with a knife.

During this brief resonant hum, the waves' amplitude naturally decreases. But if the lookalike particles do exist, they would keep the amplitude higher for longer. Physicists are currently combing through data from these events in the hope of hearing such a signal. You won't be surprised to hear that there has been no joy so far. No one said finding a hidden dimension was going to be easy.

But there is new hope, at least, with the recent invention of a so-called dark dimension. This one wouldn't be a cinch to detect either, and yet it has two big attractions. First, it could explain the nature of dark matter, the stuff we know is out there influencing the shape of galaxies through its gravitational pull but that we have failed to identify despite decades of attempts. Second, its proponents insist that simple experiments could soon reveal the presence of the dark dimension, or rule it out.

The origins of this idea lie in string theory. One of the niggles with the theory is that it predicts a vast array of possible universes, known as the landscape, depending on precisely how its extra dimensions are curled up. To combat this, Vafa initiated a programme of research a few years ago to work out which areas of the landscape – that is, which versions of string theory – can be ruled out because they don't align with our observations of the universe. Vafa dubbed these untenable parts of the landscape the "swampland".

Vafa's ongoing swampland research programme has led him to several mathematical hypotheses, one of which is the distance conjecture. This says that when a physical parameter has an extreme value, there are particular mathematical repercussions. "If some parameter in the theory is extreme, there must be another description where the physical description is simpler," says Vafa. One such parameter is the strength of dark energy, the unknown force that is pushing the universe apart. Despite operating over cosmic scales, dark energy is almost preposterously weak. Starting in 2022, Vafa applied the distance conjecture to the strength of dark energy and found something surprising: it predicted that one of string theory's dimensions would be much larger than the others and would hold a suite of particles.

COLTON STIFFLER/GETTY IMAGES

We navigate the world in three dimensions, but there may be others hidden from us

Into the swampland

Working through the details, Vafa found that, in this scenario, graviton particles with a range of masses would have been produced soon after the big bang and most would have leaked into the dark dimension, the width of which would be about a micrometre, or a thousandth of a millimetre – making it a giant among dimensions. We couldn't detect these particles directly, but we would feel their effect. As Vafa wrote in a review published this year, this dimension could explain dark matter. "This extra dimension pieces together all the properties we want dark matter to have," he says. "We don't have to postulate a new particle for dark matter, gravity itself is that particle."

Vafa's idea is based on an unproven conjecture, so it could easily be wrong. But it has the advantage of being relatively easy to check. In four-dimensional space-time, the force of gravity between two masses is inversely proportional to the square of the distance between them – this is Isaac Newton's inverse square law. When another dimension is added, however, gravity should be proportional to the cube of the separation. This effect would only show up at scales similar to the width of the dark dimension. So, to test for it, physicists would need to hold two feather-light masses about 1 micrometre apart and check if gravity adheres to the inverse square law or not.

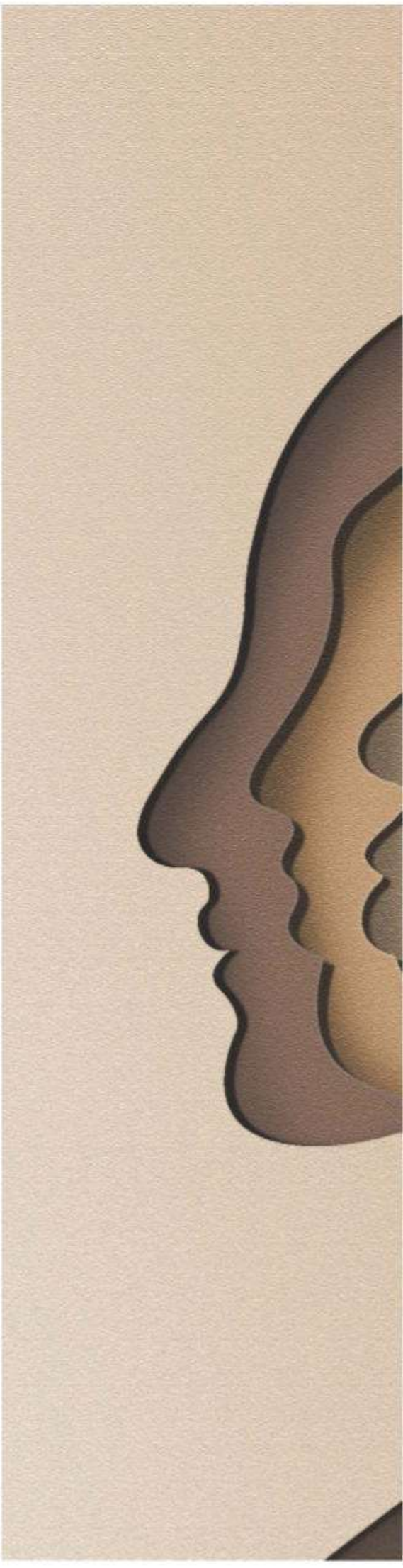
Experiments from a group of researchers at the University of Washington have already shown that the inverse square law still holds at separations of 52 micrometres. But ongoing experiments from a group in Austria, which includes Armin Shayeghi at the Austrian Academy of Science, hope to whittle that distance down. Their work involves swinging particles from a tiny pendulum set alongside another tiny mass. Changes in the force of gravity can be inferred from the swing of the pendulum. "If future experiments find that the inverse-square law is violated at extremely small distances, it will have profound implications for our understanding of the universe," says Shayeghi. Vafa reckons we could be attempting these experiments at the scale of 1 micrometre within years. "We're not too far away," he says.

Should physicists actually find hard evidence of this dark dimension, it would be an earthshaking revelation, akin to the square in *Flatland* encountering the sphere. Admittedly, it is rather hard to imagine. But scientifically, says Baker, "the confirmation that extra dimensions actually exist could solve a lot of problems." ▮

Chen Ly is a freelance science journalist based in London

The big brain teaser

Why did humans evolve such large brains? A surprising new idea gives us insight into the future of humanity, finds **Colin Barras**



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NOBODY doubts that Albert Einstein had a brilliant mind. But the Nobel prizewinner, famous for his theories of special and general relativity, wasn't blessed with a big brain. "It was smaller than average," says Jeremy DeSilva at Dartmouth College in New Hampshire.

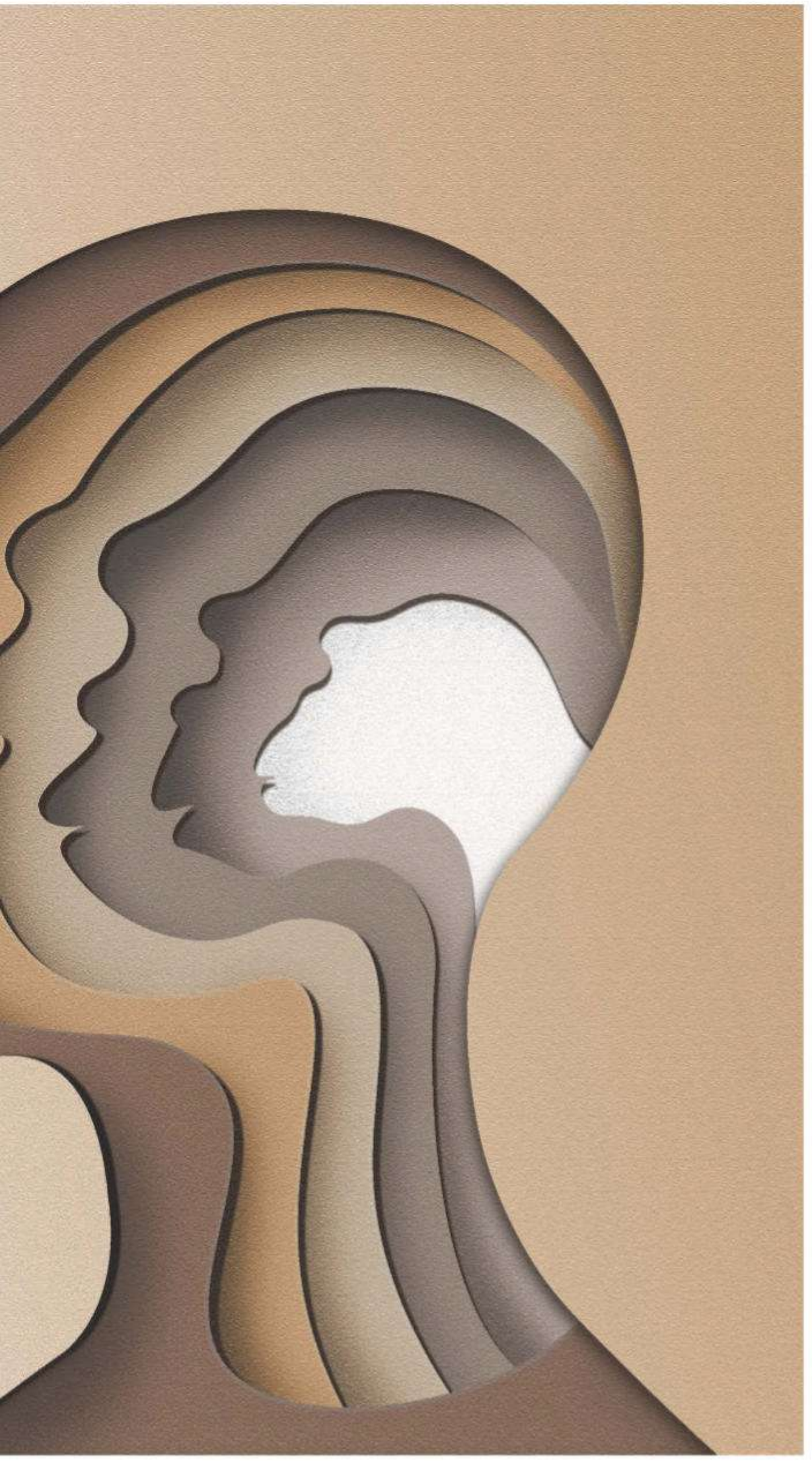
This seems surprising. Big brains are a defining feature of human anatomy, and one we are proud of. Other species might be speedy or powerful, but we thrive using the ingenuity that comes with a large brain. Or so we tell ourselves. Einstein's brain hints that the story isn't so simple – and recent fossil discoveries confirm this. Over the past two decades, we have learned that small-brained hominin species survived on Earth long after big-brained ones appeared. Moreover, evidence is growing that they were behaviourally sophisticated. Some, for instance, made complex stone tools that could probably only have been fashioned by individuals with language.

These discoveries turn the question of human brain evolution on its head. "Why would selection favour big brains when small-brained humans can survive on the landscape?" says DeSilva. Neural tissue consumes lots of energy, so big brains must surely have brought benefits to the few species that evolved them. But what?

An answer to this puzzle is beginning to emerge. It looks like brain expansion began as an evolutionary accident and then led to changes that caused this growth to spiral. Surprisingly, the sorts of changes that drove this expansion could also explain a more recent 10 per cent reduction in human brain size. What's more, this suggests our brains may shrink further still – and might even cause humanity's demise.

It is undeniable that hominin brains have grown larger through time. *Sahelanthropus tchadensis*, the oldest known hominin, which wandered northern Africa about 7 million years ago, had a brain volume of around 360 cubic centimetres. The average brain volume of a human today is almost four times that, at 1350 cubic centimetres. Granted, some of this expansion can be explained by the fact that we are larger than most of our hominin ancestors – for example, Lucy, a 3.2-million-year-old hominin, was just 1.1 metres tall. Larger animals tend to have larger brains, says Amélie Beaudet at the University of Cambridge. "But we do need another explanation because, at some point, you see that body mass is not really increasing in ancient humans, but brain size is increasing a lot."

Until a few decades ago, the explanation seemed obvious. Many researchers assumed that the hominin evolutionary tree looked fairly simple, particularly following the evolution around 2 to 3 million years ago of the first species belonging to the genus *Homo* from the more ape-like hominins. The idea was that only one species could occupy the environment at any one time, says Philipp Gunz at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. So, *Homo habilis* appeared to thrive until it was replaced by *Homo erectus*, which was superseded by *Homo heidelbergensis*, which itself was supplanted by our species, *Homo sapiens*, in Africa and by the Neanderthals in Eurasia. In each case,



the successor species had a larger brain than its predecessor. Researchers rarely questioned the idea that big-brained humans were smarter and evolutionarily superior to their small-brained ancestors.

Then came some extraordinary discoveries that undermined this assumption. It began 20 years ago when researchers in Indonesia discovered *Homo floresiensis*, a 1.1-metre-tall human with a tiny, 425-cubic-centimetre brain. It survived until astonishingly recently – about 50,000 years ago, according to current estimates. This means that long after our species appeared more than 300,000 years ago, there were small-brained humans on Earth. And *H. floresiensis* wasn't alone. A further discovery around five years ago revealed another small hominin, *Homo luzonensis*, survived in the Philippines until around the same time. Then there is the diminutive *Homo naledi*. Discovered in 2013, it had a brain volume of no more than 550 cubic centimetres – literally pint-sized – but lived in southern Africa alongside our big-brained species until at least 235,000 years ago.

If these discoveries weren't remarkable enough, we now have signs of something even more astonishing: small-brained hominins seem to have been capable of sophisticated behaviour. A striking example of this comes from a site called Gona in Ethiopia. *H. erectus* living there about 1.6 million years ago produced "Acheulean" stone tools. These artefacts, which include teardrop-shaped hand axes, are so difficult to make that experiments suggest it would have required at least rudimentary language to teach and learn the skill. Given that, you might assume the individuals at Gona had large brains. But a 2020 study revealed that at least some of them had brains that were less than half the size of those of people today.

Last year brought a similar revelation. Before hominins made Acheulean tools, they made simpler – but still quite complex – "Oldowan" tools. It has long been thought these were largely the handiwork of *H. habilis*, a species with a brain volume of around 550 cubic centimetres. But at a site called Nyayanga in Kenya, researchers reported finding Oldowan tools up to 3 million years old in association with fossils of *Paranthropus*, a hominin with a brain volume as low as 450 cubic centimetres. Despite its small brain, says Beaudet, *Paranthropus* may have made Oldowan tools.

The most eye-catching claims of all involve *H. naledi*. Researchers have spent a decade analysing a cave in South Africa ›

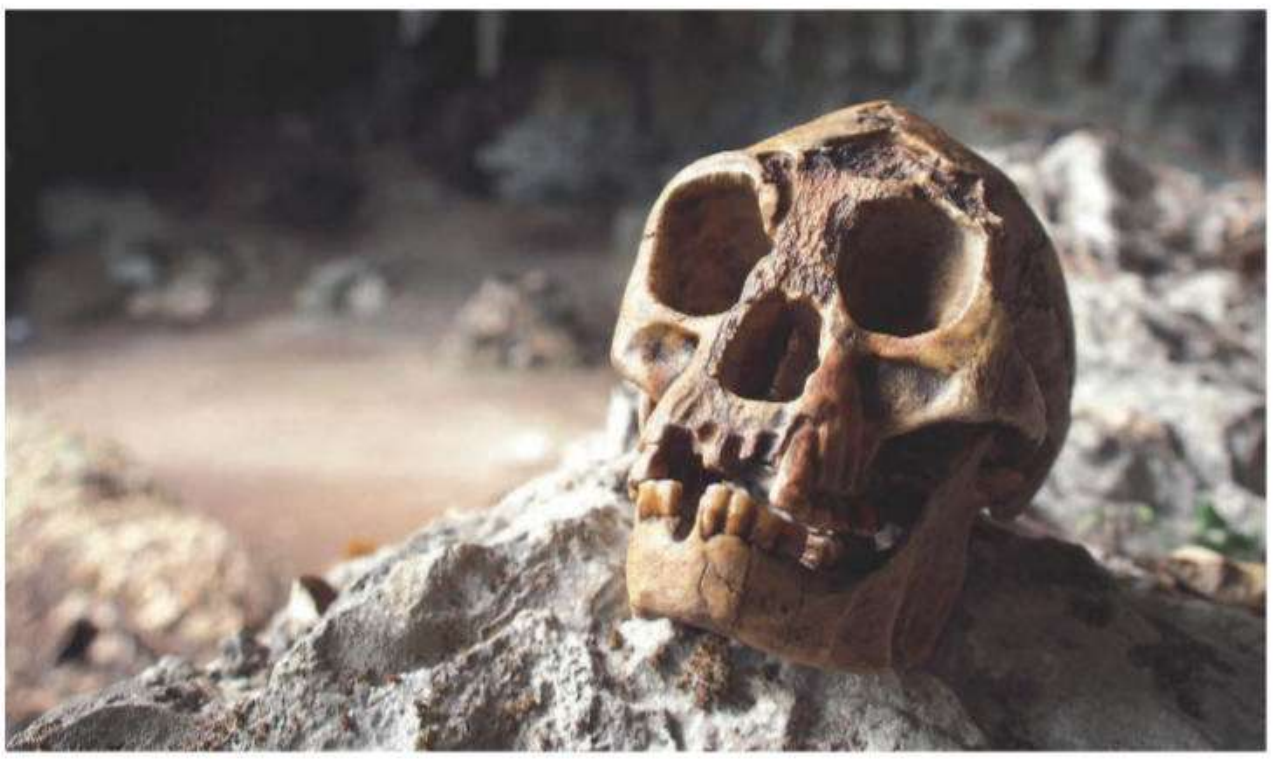
containing the remains of more than 15 ancient individuals. Last year, the team concluded that the site reveals evidence of remarkably sophisticated behaviour: *H. naledi*, they argued, had used torchlight to carry dead individuals into a deep burial chamber, the walls of which they had decorated with etchings. For most researchers, this is a step too far. "I don't believe *naledi* could bury its dead or make engravings in caves," says Gerhard Weber at the University of Vienna in Austria. Nevertheless, the finds at Gona and Nyayanga suggest that hominins didn't require an overabundance of neural tissue to behave in complex ways. This makes the evolution of large brains a bit of a head-scratcher.

When bigger isn't better

Adding to the puzzle is the fact that big brains carry some clear disadvantages. They are demanding to run: ours consume around 20 per cent of our daily energy intake despite accounting for just 2 per cent of our body mass. Moreover, a baby with a large brain is tricky to deliver and to raise. "Childbirth is difficult," says DeSilva. "And when you're trying to feed this infant with its growing brain, it's an energetically exhausting endeavour."

Nonetheless, hominin brains did evolve to be larger over time. At a conference of the European Society for the Study of Human Evolution in Denmark last year, Thomas Püschel at the University of Oxford and his colleagues showed that this trend was mostly driven by changes within particular species.

"Adding to the puzzle is the fact that big brains carry some clear disadvantages"



JAVIER TRUEBA/MSF/SCIENCE PHOTO LIBRARY

Despite its tiny brain, *Homo floresiensis* survived long after our species evolved

For example, when *H. erectus* first appeared in the fossil record about 2 million years ago, its brain volume was as little as 550 cubic centimetres. By the time the last *H. erectus* were walking Earth, some 108,000 years ago, that volume had doubled.

At the same conference, Weber presented an analysis showing that the rate of brain expansion hasn't been constant, though. Between 7 million and 2 million years ago, average hominin brains increased modestly in size – from about 360 to 450 cubic centimetres. Then they enlarged at a faster rate, ballooning to 1350 cubic centimetres 110,000 years ago. After that, the rate accelerated even further, with brain volume reaching a peak of 1500 cubic centimetres around 50,000 years ago, late in the Stone Age.

One popular hypothesis ties this expansion to changes in diet. "The idea is that when hominins started to eat meat on a more regular basis, we had the energy to develop a bigger brain," says Beaudet. This could explain how brain expansion happened, but not why. In other words, what was the evolutionary advantage of diverting that extra energy to the brain rather than to other parts of the body?

An alternative hypothesis does address the question of why. It states that some hominins began living in bigger social groups and grew larger brains to cope. "If your social environment is more complex, you may need a bigger brain to understand how to live with that complexity," says Beaudet. But there are problems with this idea too. For instance, it implies that brain size should correlate with social group size across primate species – but researchers have failed to find this pattern.

It may be a mistake to pin brain expansion on a single factor. Better diets and larger social groups probably played their part, but it seems likely that there was more going on. One possibility is that brains and behaviour became caught up in a positive feedback loop. Perhaps small-brained hominins developed new tools and basic language skills, thereby boosting their odds of survival. If individuals with slightly larger brains found it easier to master these technologies and behaviours, average brain sizes would have risen as time passed. And as brains grew larger, the population would have found it even easier to improve their tool-making and language skills, leading to further selection for larger brains and making tool production easier still. "Evolution doesn't just invent new brain structures and suddenly you can speak or whatever. It's the other way round," says

JAVIER TRUEBA/MSF/SCIENCE PHOTO LIBRARY; THE PRINT COLLECTOR/ALAMY

Left: Liang Bua cave in Indonesia where *Homo floresiensis* was first found. Above: Small-brained hominins made complex tools

Christoph Zollikofer at the University of Zurich in Switzerland. "You start speaking and then this creates a new cultural environment under which there are new selective pressures that favour new brain structures."

Accidental advantage

This still doesn't explain why bigger brains would have made tool-making or language easier to master. But Beaudet has an idea. Let's assume a meat-rich diet led to an energy surplus, and some of that energy fuelled brain growth – simply because the extra energy had to go somewhere. But, as brains expanded, they ran into a problem. "At some point, just because the brain is getting bigger, you have no space in the brain case," says Beaudet. The surface of the brain – which was already folded in small-brained humans – would have gained an even more elaborate pattern of folds and furrows as it pressed against the skull. This folding potentially brought neurons from distinct brain regions into closer physical proximity, she says, allowing for greater connectivity between those regions. Purely by chance, some of these connections might have made it easier for humans to talk or make tools. In other words, brain expansion may initially have had no survival advantage, but then serendipitously acquired one – at which point natural selection would have kicked in.

This line of reasoning could even help explain why Einstein's brain, at about 1290 cubic centimetres, was on the small side – and why women are just as smart as men despite having slightly smaller brains. If evolution were mostly about favouring better-connected brains rather than bigger ones, brain size could vary somewhat without affecting performance. Even so, size clearly matters at least to some extent, which raises questions about a curious event in our recent evolutionary history when brains shrank, going from 1500 cubic centimetres to just 1350 cubic centimetres – the volume we have today. Surprisingly, this shrinking may have had the same underlying cause as brain growth: the development of new technologies and sophisticated behaviours.

In a 2021 study, DeSilva and his colleagues analysed data from hundreds of ancient skulls to work out exactly when this shrinking event occurred. "We were surprised how recent it was: within the 3000-to-5000-year range," he says. This suggests brains downsized at a pivotal moment – just as the first civilisations began to appear and new technologies, including writing, emerged. DeSilva thinks this is no coincidence. He argues that, with these innovations, humans inadvertently relaxed the pressure on evolution to favour individuals with a big brain. For example, writing allowed people to store some of their accrued knowledge externally instead of committing it to memory. Complex societies, meanwhile, meant that the decisions crucial to survival were increasingly taken at a group level. As a consequence, the cognitive demands on individuals lessened and brains could shrink. "It's a really nice narrative," says Püschel – although he cautions that it must be tested more thoroughly.

Nevertheless, researchers do now entertain the idea that changes in society and technology could influence evolution and shape our brains. For some, the big question is whether that is always to our benefit. Weber worries that it might not be. He has suggested that, in the future, it might become even less important for humans to maintain large brains because of the rise of artificial intelligence. "What really worries me is machines that can produce machines," he says. "If an AI can produce the next AI without our intervention, the question is: what is our role then?" In a study published last year, he raised the possibility of a "post-human era" in which AI and other technologies have produced "abiotic beings" and replaced humans.

Others are less concerned. Even if human brains shrank in the past as individuals began to rely more heavily on new technologies, humans clearly continued to flourish. Beaudet thinks we should view AI as the latest in a long line of hominin technologies, stretching back to the pounding stones our ancestors used to process food. Just like those stone tools, AI might simply improve the efficiency with which we carry out certain tasks, affording us more time to dream up even more technologies. "It's been like this since the beginning of the human story and I think it will never stop," she says. "I am a bit worried, but I don't think AI will rule the world." ▮

Colin Barras is a freelance science writer based in Ann Arbor, Michigan

Going viral

With all the excitement over the health benefits of the gut microbiome, have we been missing a vital piece of the picture, asks **Linda Geddes**

WITHDRAWN and anxious, the mice in John Cryan's lab were behaving like you or I might if we had experienced workplace bullying and thought we might encounter the bully again.

The good news, believe it or not, was that some of these rodents were also being fed a slurry of microbes derived from their own faeces. Unpalatable as this sounds, it had a surprisingly positive effect on their behaviour. "It was phenomenal," says Cryan, a neurobiologist at University College Cork in Ireland. "We found that these stress-induced changes in behaviour normalised – they started to behave just like normal animals."

Even more surprising, this mental transformation wasn't brought about by changing the bacteria in their guts, but by tinkering with another crucial facet of the microbiome whose importance is only now being recognised: viruses.

It turns out that we are riddled with

SAM FALCONER

these. Not the ones that make us unwell, but trillions of stowaways that play a crucial role in cultivating a beneficial microbiome and making us healthier in turn. Recent research shows that the influence of this "virome" can be found across the body, from the blood to the brain. The hope is that by tweaking it, we could find new ways of treating various ailments, from inflammatory bowel disease and obesity to anxiety.

The past decade has seen a surge of interest in the microbiome – all the really tiny things that live on and in us – but this has largely focused on bacteria. The assumption until recently was that viruses were mainly transitory visitors, using us to propagate themselves, making us ill in the process.

In the early to mid-2000s, however, just as efforts to characterise the numerous bacteria in our bodies were taking off, some researchers began wondering if viruses might also constitute a longer-term component of our microbiomes.

Among them was David Pride, then a young microbiologist whose first foray into this hidden world was "quite frankly, the stupidest experiment we'd ever done", he says. "We literally took a bunch of tubes, spat in them, and then brought them down to the electron microscope to see what we could find."

This proved a revelation. "There were so many viruses, we couldn't miss them," says Pride, now at the University of California in San Diego. Buoyed by this finding, he and his colleagues began scrutinising other body fluids and found viruses everywhere, from blood to the fluid surrounding the brain. "Our hypothesis went from 'gee, we don't know if there are any viruses anywhere' to 'viruses are everywhere, and there's probably no place where there aren't any viruses'," says Pride. It is estimated that each of us is carrying around 380 trillion viruses – with these nanoscopic entities outnumbering bacteria by a ratio of 10:1.

But finding viruses is one thing; figuring out what they are and what they are doing is quite another. Due to technical challenges the vast majority of viruses in the human gut haven't yet been identified, meaning that research on the virome has lagged considerably behind that on the bacterial component of our bodies. Even so, genetic sampling of the gut virome has thrown up surprises.

"We started with the idea that we were going to be sequencing viruses that infect human cells, but it turned out that 97 per cent of what we were sequencing were bacteriophages – viruses that infect bacteria," says Pride.

It was, he says, "an extraordinarily disappointing moment. But I brushed it off and said, 'well then, let's figure out how bacteriophages are important to humans'."

Phages, as they are known, have bulbous heads consisting of genetic material encased in a protein shell and leg-like tail fibres, which ›

"Trillions of viral stowaways play a crucial role in cultivating a healthy microbiome"

are used to penetrate the cell walls of bacteria. All of which means they bear an uncanny resemblance to ticks – parasites that suck blood from animals. In fact, some researchers think phages should be classified as bacterial parasites, as their life cycle involves attaching to susceptible bacteria and hijacking the cellular machinery to produce new copies of themselves. Sometimes they kill their hosts once this goal has been achieved – the word "phage" derives from the Greek "phagein" meaning "to devour".

Other types of phages, known as temperate phages, integrate their genomes into those of their bacterial hosts, remaining dormant until some external event triggers them to start replicating, or peacefully co-existing alongside the bacterium, shuttling their offspring out of their host without harming it.

Phages are thought to outnumber any other biological entity on the planet and can be found wherever bacteria are present, from the deepest ocean and soil to our guts.

"What is interesting about bacteriophages and other viruses in the gut is that every person has their own unique set, with almost no overlap between different people," says Evelien Adriaenssens at the Quadram Institute in Norwich, UK. One of her interests is understanding where these viruses come from, which she is investigating by analysing stool samples from women and their newborn infants and following them over time. "What we see is that healthy infants are born without a noticeable virome, then, in the first couple of weeks of life, they acquire one, together with the bacteria and all of the other components of the microbiome," says Adriaenssens.

First to arrive are the temperate phages, most likely piggybacking on the genomes of the earliest bacteria that colonise a baby's gut. Over the next few years, these phages are gradually replaced with varieties more in line with those of the adult gut, possibly linked to changes in intestinal bacteria as children grow older. Once established, this virome appears to remain relatively stable throughout life.

Despite their ubiquity, phages are extremely picky about which bacteria they infect. "Even within [bacterial] species, they only infect certain strains, so they are exquisitely selective," says Colin Hill, who is also at University College Cork.

However, just because the phage population follows changes in the bacteria that gradually colonise our bodies, this doesn't mean they are inert passengers. Once established, phages may play an important role in maintaining the structure and function of bacterial communities. Although phages prey on bacteria, it wouldn't be in their interest to destroy all the individuals in a community. In certain situations, phages may even benefit their host bacteria. For instance, Pride has found phages in saliva that have genes that may help the bacteria they infect to evade the immune system – genes presumably acquired from bacteria that they infected previously.

Bacteria have also evolved strategies to evade or respond to phage attack, and phages have done likewise with countermeasures. We increasingly suspect that this ongoing arms race may help to keep bacterial numbers in check and boost the health of surviving bacteria. "They're partners and need each other to co-evolve and to stay fit," says Hill.

Another way to view phages is as bacterial gardeners. By weeding out weak bacteria, they create space for others to grow and flourish. "In a system where you have a combination of bacteria and bacteriophages, you usually find a larger diversity of bacteria," says Adriaenssens.

CORINNA WHITFIELD/MILLENNIUM IMAGES, UK

Viruses in the gut seem to influence how our brains respond to stress

It is widely agreed that a more diverse microbiome is a healthier one – and this includes viruses too. Indeed, a 2023 study on centenarians suggests that longevity and a healthy lifespan may be linked to having a greater diversity of viruses in the gut.

The virome's impact might also be felt in the brain. Our gut microbes produce some of the same neurotransmitters that are made in the brain, and may also affect mood by triggering inflammation. But while most research on this "gut-brain axis" has focused on the role of bacteria, there are tantalising hints that phages may be implicated as well.

In a 2022 study, José-Manuel Fernández-Real at the University of Girona in Spain and his team analysed stool samples from more than 1000 volunteers to check whether the types of phage in their guts correlated with an ability to learn and retain new information. They found that people with higher levels of a class of phages known as Caudovirales did better in cognitive tests, whereas those with lots of phages in the Microviridae family took longer to complete the tests and retained less information.

Next, they transplanted faecal samples from volunteers with high Caudovirales levels into the guts of mice to see if this altered their cognition. "We were very surprised," says Fernández-Real. Not only did the test scores of the animals improve following the transplant, but genes relevant to learning, memory and neuronal development became more active in the prefrontal cortex – an area associated with planning, decision-making and memory. Although the team couldn't be certain that these improvements were purely down to changes in the virome, further experiments in fruit flies fed a diet rich in Caudovirales phages suggested that their memory also improved.

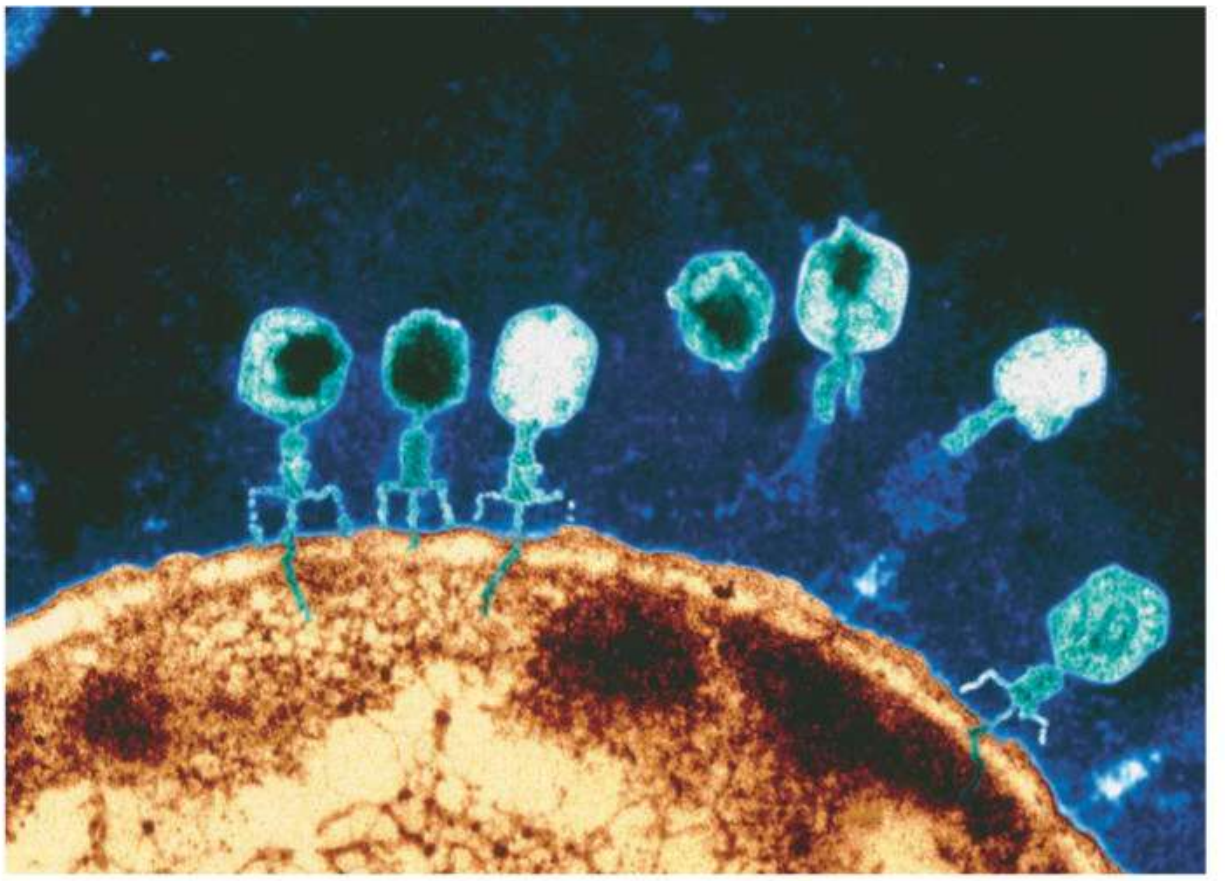
Cryan's work is also shining a light on the role of phages in brain function. About 15 years ago, he discovered that stress could affect the composition of microbial communities in the gut. Further experiments suggested that boosting the levels of certain gut bacteria in mice could buffer them against some of the negative effects of stress – something that appeared to be mediated through the vagus nerve, which ferries messages between the brain and the rest of the body.

"It was a defining moment," says Cryan. "We showed that the microbiome is regulating the

stress response and you can target the microbiome to alleviate the stress response."

To investigate whether phages might provide a means of doing this, Cryan and his colleagues subjected mice to a scenario designed to induce social stress by placing them in a cage with an aggressive peer. The mice are separated before any physical harm occurs and the victim is then housed within sight and smelling distance of the bully. Usually, mice exposed to such treatment become anxious and socially withdrawn. However, if at this stage their microbiomes are supplemented with viruses taken from their guts before the stressful encounter, they spend more time out in the open, travel more and, if placed in a cage with a different mouse, they interact with it more.

Further work revealed this supplementation buffered the effects of stress on the mice's immune cells, while gene activity in the hippocampus and the amygdala – brain areas associated with memory, fear and social behaviour – was normalised. "We think the viruses are affecting the bacteria, which are affecting the brain. But the viruses are a key regulator of the bacteria," says Cryan.



EYE OF SCIENCE/SCIENCE PHOTO LIBRARY

Viruses called phages "sit" on the cell wall of a bacterium and inject DNA into it

Stress test

He believes that virome transplants could someday provide an alternative means of treating stress-related disorders. "We're looking at whether we could generate some form of intervention that could be given to someone who knows they're going into a stressful situation that could help them manage that stress better." One attraction of using phages to do this is their specificity. "If you can identify specific bacteria that you want to target in specific situations, bacteriophages are a great tool to help you do that," says Cryan. "The problem that we have in neuroscience right now is that we don't yet know what are the specific bacteria that we want to shut out."

However, there are other scenarios where we do know this. One is when tackling infections caused by antibiotic-resistant bacteria. "In the textbooks, phage therapy is a dream solution because if you've been infected with a particular pathogen and you have a phage that kills it, you can wipe out that pathogen without affecting the other bacteria in its environment, whereas an antibiotic kills a lot of other things as well," says Hill.

Earlier this year, the UK's Science, Innovation and Technology Committee published a report calling on the government and regulators to do more to advance the use of phages to treat antibiotic-resistant bacteria. Phage therapy has been used in parts of eastern Europe and Russia for decades. For instance, the George Eliava Institute of Bacteriophages, Microbiology and Virology in Tbilisi, Georgia, has been using phages to treat bacterial infections since the 1920s and today treats patients from across the world at its Eliava Phage Therapy Center. "We have six ready-to-use phage preparations, and if those don't work against a clinical sample, we will prepare a specific phage for a patient," says Mzia Kutateladze, the institute's director.

However, medical systems elsewhere have been slow to embrace phage therapy – in part because large clinical trials haven't been published to demonstrate its efficacy. Regulators also tend to want to know the precise dose and mechanism through which interventions work, which are difficult to map for cocktails of phages, says Hill.

There may be an alternative: Hill and his colleagues are characterising the enzymes that phages of *Clostridioides difficile* bacteria use to break open their hosts' cell walls and escape. *C. difficile* is a leading cause of healthcare-associated infections, and antibiotic resistance is a growing problem, but if these enzymes could be purified and delivered to the bacteria, they could kill them without damaging the wider microbiome. In the long term we could develop cocktails of phages or their enzymes to tweak the composition of our microbiomes and treat mental health conditions such as anxiety, or other conditions associated with an unbalanced microbiome, such as inflammatory bowel disease and obesity.

For now though, our best bet for looking after our gut virome seems to be via what we eat. Though it is too soon to say precisely which phages are associated with good health and how to boost their growth, recent research has provided some clues. Phages tend to hitch a ride with their bacterial hosts; they are abundant in bacteria-rich foods, particularly in fermented products such as sauerkraut, kefir, kimchi, wine and fermented dairy products, including cheeses. Fernández-Real, for instance, found that participants in his study who had high levels of beneficial Caudovirales phages reported regular consumption of dairy products. Certain foods may also be able to change the abundance of gut bacteria by altering the behaviour of dormant phages. For example, a 2020 study found that the sugar substitute stevia triggered certain types of phages to wake up and start killing their hosts.

Although it is early days, one thing is clear: viruses are far from one-dimensional villains. "Viruses have historically had a really bad rap, and covid only made that worse. But as our data clearly show, we cannot forget about the role of viruses in maintaining overall health and how we manage stress," says Cryan. "It is time they came into the spotlight." ▮

Linda Geddes is a freelance writer based in Bristol, UK, and the author of *Chasing the Sun*

The back pages

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Debunking gardening myths

Coming up roses

Social media assures us that we can grow a rose cutting in a raw potato. **James Wong** goes looking for any evidence this works

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on and Instagram @botanygeek

SOMETIMES it is the really counterintuitive ideas in horticulture that ironically turn out to be the most effective. So about a decade ago, when the internet was suddenly flush with a curious new technique for using potatoes to propagate rose bushes, I was keen to test it out.

Here is the basic idea: instead of inserting the snipped ends of rose cuttings into bare soil as is standard practice, you poke them into whole, raw spuds, which are then buried in pots of compost. Supposedly, this gives home gardeners better results.

Raking up millions of views, posts espousing this idea soon spawned all manner of variations, some involving a coating of honey, and a few devotees not burying their potato-rose union at all, just sitting it on a windowsill. There are even viral time-lapse videos purporting to show these roses miraculously blooming just weeks later. A decade on, and this interest has made it out of internet memes and into mainstream newspapers, today seemingly part of standard horticultural advice.

Now, it doesn't help the potato-rose cause that most of the viral videos popularising the idea are poorly produced fakes, showing roses sprouting the roots of bean plants, or flowering at impossibly small sizes. But the weirdest thing about these memes is that they don't even explain what the benefit of doing this is. Do more cuttings survive when using spuds? Do they root faster? Are they more resilient to drying out or to fungal infection? Maybe all four?

SHUTTERSTOCK/LIGHTFIELD STUDIOS

While I could find no published trials in academic literature, and no explanations of how this technique might be beneficial, after some digging, I did find one or two historical accounts of using potatoes to help prevent the sliced ends of cuttings from drying out when transported long distances. Indeed, some of the first Japanese flowering cherry trees to reach Britain in the early 20th century were transported as cuttings of dormant twigs in this way, on the Trans-Siberian Railway.

So I decided to run a small home trial. I planted three cuttings each of three common rose cultivars, both using the spud technique and the traditional method. I am afraid to say the results were boringly predictable. None of the spud-poked rose cuttings worked, drying up and turning brown within a week or so, while the traditional cuttings had a 100 per cent success rate. In fact, the only things I successfully grew by the potato method were the potatoes!

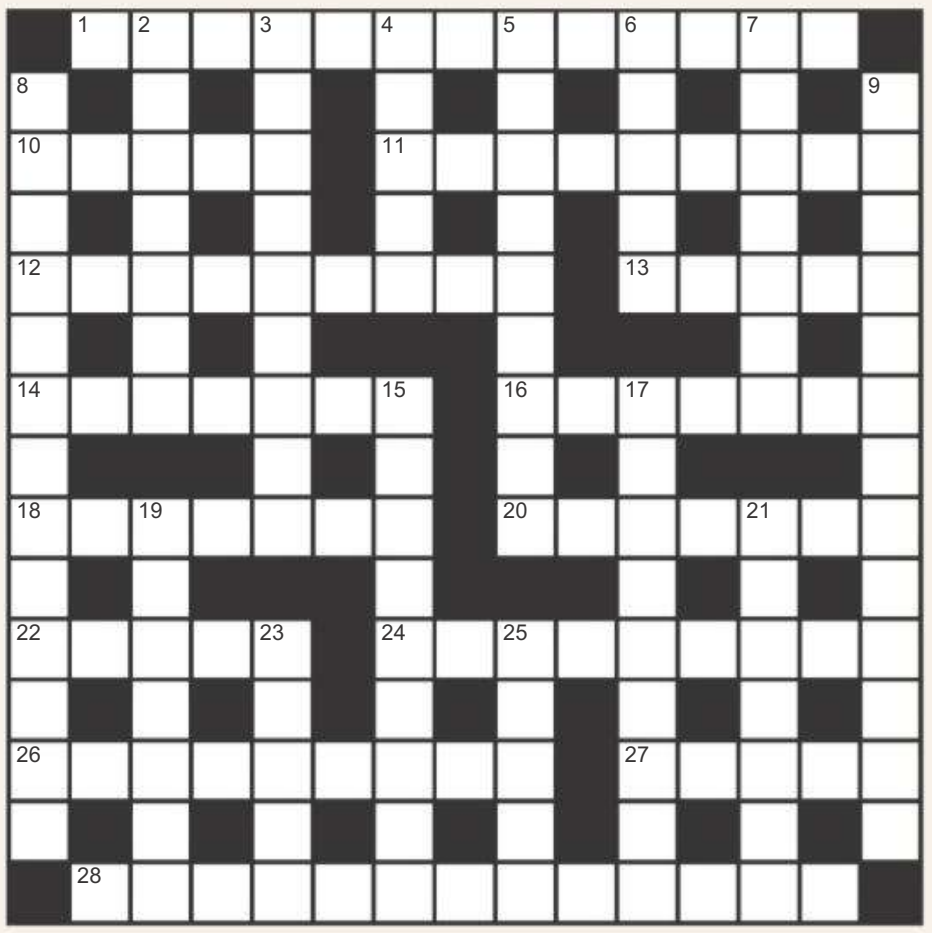
OK, this was admittedly a minuscule trial by academic standards, but the hallmark of good science is reproducibility. And today, if you try searching "rose cutting potatoes" on X, guess what? You will be faced with posts from people all over the world showing pots of very healthy potato plants – but absolutely zero living rose bushes. ▮

These articles are posted each week at newscientist.com/maker

Debunking gardening myths appears every four weeks

Next week
The science of baking

Quick crossword #162 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Potassium hydroxide (7,6)
10 Major blood vessel (5)
11 Characteristic of a geometric curve (9)
12 Short-range wireless technology (9)
13 Rapid; lively (5)
14 Kidney component (7)
16 Lasting 360 minutes (3-4)
18 Encrypts (7)
20 Arranging; filing (7)
22 Doughnut shape (5)
24 2010 Christopher Nolan sci-fi film (9)
26 Nearest major galaxy to the Milky Way (9)
27 Microorganism used in baking and brewing (5)
28 Instrument for measuring voltage (13)

DOWN

2 Device for pushing atmospheric gases (3,4)
3 Broken; smashed (9)
4 Mature form (5)
5 Delusional mental state (9)
6 Silicate mineral, $Al_2SiO_4(F,OH)_2$ (5)
7 Siege engine of ancient Rome (7)
8 Net zero (6,7)
9 Remove H (13)
15 UK healthcare helpline (3,6)
17 Plant with the ability to survive in a low-water habitat (9)
19 Short-distance communications system (2,5)
21 Copy; mimic (7)
23 Radial rod (5)
25 Prefix used interchangeably with "nitrile" (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #260
set by Bethan Ackerley

1 Neanderthal 1, the type specimen of *Homo neanderthalensis*, was found in what present-day country?

2 In what year was the Mars Global Surveyor spacecraft launched?

3 Which chemist determined the structure of penicillin and vitamin B12?

4 Which class of hormones regulates plant growth?

5 Animals that eat hard-shelled or exoskeleton-bearing organisms are known as what?

Answers on page 47

BrainTwister
set by Peter Rowlett
#28 Dice differences

We play a game starting with a counter in the centre of a row of squares. Every turn, we each roll a six-sided die. If the difference between the values rolled is 2 or less, the counter moves one place to the left. If the difference is more than 2, it moves one place to the right. I win if the counter reaches the left-hand end of the row and you win if it gets to the right.

Am I offering you a fair game or does one direction have an advantage?

The game is adjusted so that if the difference is 2 or less, the counter still moves one place to the left, but if the difference is more than 2, it moves two places to the right. Under these rules, what is the smallest number of rolls after which the counter could return to its starting position?

Is this adjusted game fair?

Solution next week

Breaking the ice

When I look for ice cubes for an evening gin and tonic, I often find they have shattered in the mould. What causes this?

Ron Dippold
San Diego, California, US
I had this problem just last month. Shattered ice waters the gin and tonic down too quickly. It is an affront to civilisation, so I did a bit of research and experimentation!

First, it is helpful to consider how ice forms in a mould. Water freezes from the outside in, and most importantly, it expands by about 10 per cent when going from liquid to solid. So, at some point, the ice in a hard mould starts expanding upwards since there is nowhere else to go. As a result, if this expansion gets impeded, the ice is likely to crack. It can also crack when you attempt to remove it from a mould. Ice is semi-plastic, so it can change shape without breaking, but if it deforms too fast, that will also make it crack.

So what makes cracking more likely? Assuming you have a normally operating freezer, there are three common reasons. The first is minerals in the water causing weaknesses in the ice.

"Ice is semi-plastic, so it can change shape without breaking, but if it deforms too fast, it cracks"

The second, and most common, reason is a build-up of minerals on the mould walls. The third is oxygen in the water.

Mineral build-up on the walls of a mould grabs the ice and keeps it from moving upwards when it wants to expand. Excessive minerals in the water cause "grain boundary cracks" – where there are so many grains in the ice that it finds it easier to fracture than expand. Oxygen in the water similarly creates weak spots in the ice. In retrospect, I have seen this problem get better or worse as my water supply changes.

Luckily, there are several solutions. The easy way is just to use a soft silicone mould – if the ice can just expand evenly, the pressure won't be a problem. The second solution is to occasionally wash your existing mould with hot water and vinegar to remove mineral build-up. That worked for me. The next thing to do would be to filter and boil your water to remove minerals and oxygen. I hope this works for you. Cheers!

Robin Maguire
Hobart, Tasmania, Australia
Ice cubes shatter in the mould because, unlike most substances, water at 0°C (32°F) expands as it transitions from liquid to solid – which is why ice floats on ponds. As the water in the mould cools, it will lose heat through the outer surface, which will freeze first. As the liquid interior subsequently freezes, it will expand, placing the prefrozen exterior in tension and rendering it liable to shatter. As with all brittle materials, anything that can initiate a tiny crack could trigger this – for example, a speck of impurity or the act of removal from the mould.

Tempered glass uses the same effect in reverse. It is made by spraying hot glass with a fluid, causing the outer surfaces to cool and solidify quickly. As the hotter interior then cools and sets, it shrinks. This places the exterior into compression, a state in which cracks don't propagate, so shattering will be strongly resisted.

ANDREAS VON EINSIEDEL/ALAMY

This week's new questions

Cleaning up **I have a stainless steel kitchen sink. When I clean it with bleach, leaving it instantly gleaming, what happens to the particles that were staining it?** ***Patrick Lowry****, Falmouth, Cornwall, UK*

Switched on **Will we ever be able to tell if an AI gains consciousness?** ***Xavier Sainton****, Troyes, France*

How does a dose of bleach leave a stainless steel sink gleaming like new?

Clever question

Once life is established, is the evolution of intelligence inevitable? (continued)

Garry Trethewey
Cherryville, South Australia
Probably not. Wings have evolved four times – in birds, bats, pterosaurs and insects. Legs and eyes have also evolved multiple times. Swimming ability has also evolved many times.

But intelligence has only evolved once, very recently. Is it useful? Is it a survival trait? Is it somehow better than not-intelligence? Given the 8 billion of us versus the vastly greater numbers of microbes and how long they have been around, I would put my money on the microbes.

And if we take a lead from the search for extraterrestrial intelligence, there is a notion that even if technological intelligence develops in a species, that species will wipe itself out relatively rapidly, or at least put itself back into an equivalent of the Stone Age. Sound familiar?

Graham Watson
London, UK
I say no. The dinosaurs had 165 million years and never came anywhere close to evolving what we would regard as intelligence. While it is a bit of jump from agriculture, I am designating intelligent life as the ability to use radio telescopes, as it will be the technology we use to contact other life forms.

The low chance of intelligence evolving is, I say, the reason for the Fermi paradox – the gap between life in the universe looking highly likely and the lack of evidence of advanced aliens. Intelligent life is so rare and fleeting the chances of two such species existing in the same time period within range of each other is vanishingly small.

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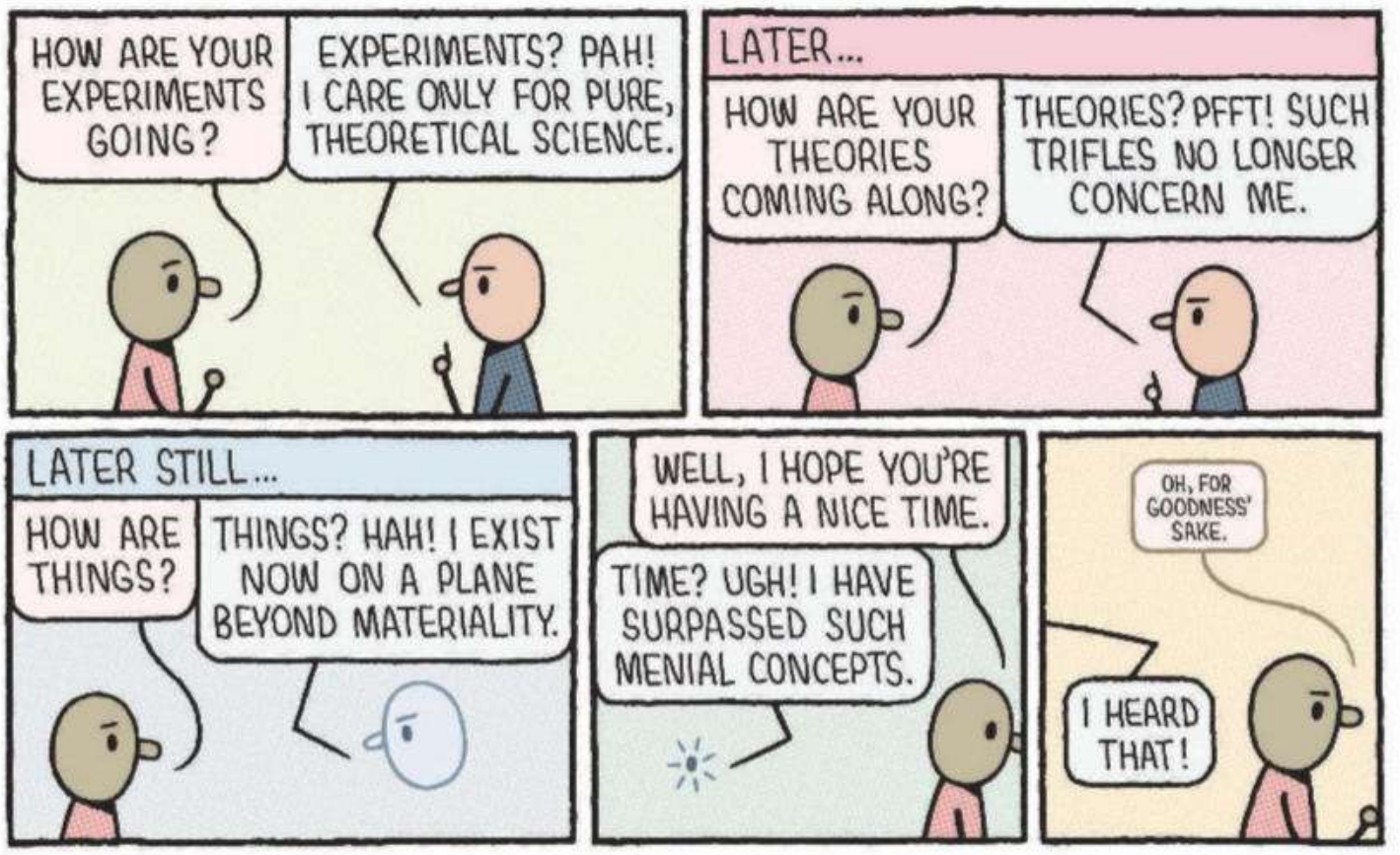
HOW ARE YOUR EXPERIMENTS GOING?
EXPERIMENTS? PAH! I CARE ONLY FOR PURE, THEORETICAL SCIENCE.
LATER...
HOW ARE YOUR THEORIES COMING ALONG?
THEORIES? PFFT! SUCH TRIFLES NO LONGER CONCERN ME.
LATER STILL...
HOW ARE THINGS?
THINGS? HAH! I EXIST NOW ON A PLANE BEYOND MATERIALITY.
WELL, I HOPE YOU'RE HAVING A NICE TIME.
TIME? UGH! I HAVE SURPASSED SUCH MENIAL CONCEPTS.
OH, FOR GOODNESS' SAKE.
I HEARD THAT!

David Smith
Alnwick, Northumberland, UK
I am surprised that answers to this question didn't consider the slime mould as an example of single-celled intelligence. Diffuse or blobby, brainless and supremely democratic, it always gets its meal.

Perhaps it is time to update the biblical proverb: "Go to the ants, thou sluggard; consider her ways and be wise". How about: "Go to the slime mould, thou dullard, consider his/her/its/their ways!"

Playing it cool

Is it more efficient to leave the fridge briefly open when I am pouring milk for my tea or to close and reopen it, given that warm air is introduced whenever the door is opened? (continued)

Wai Wong
Melbourne, Australia
I used to wonder why, in summer, uncooked fish and tofu in the fridge more easily acquire a foul smell, while that rarely happens on cold days. After all, a fridge is supposed to maintain a constant temperature irrespective of the outside temperature. After some research, I found the reason – on warm days, the foodstuff is already closer to spoiling on its way home, and several exposures to warm air rushing into the fridge may be enough for it to go bad.

"I always put the milk carton closest to the edge of the fridge door so that I can fish it out in a couple of seconds when the door is ajar"

It doesn't take much heat to reach this point – a rise of just a couple of degrees and food can spoil in a few hours. Just as our face and hands can feel the cool air when the fridge door is open, the bacteria on the surfaces of food can feel the warm air.

Now I always put the milk carton closest to the edge of the door so that I can fish it out within a couple of seconds when the door is ajar. Before cooking a meal, I always plan ahead so that all the necessary ingredients can be retrieved in one go in as little time as possible. Spoilage isn't totally avoided, but it happens much less often with those measures.

Jacqueline Christmas
Crediton, Devon, UK
This is in response to Maurice Gallagher, who suggested giving up milk in coffee because it is "more efficient, better for your health and more environmentally friendly" to take your coffee black.

The milk in my coffee comes from the fields around my house via a dairy within walking distance. The coffee, on the other hand, comes from South America. I suggest that, on food-mile environmental grounds at least, it would be better to give up the coffee than the milk. However, if you want to be really environmentally friendly, then we should all only drink tap water.

Though even that isn't always a great choice. Recall the recent situation in Brixham, UK, where residents were advised to boil water after contamination. ▮

Answers

Quick quiz #260 *Answers*

1 Germany
2 1996
3 Dorothy Hodgkin
4 Auxins
5 Durophages

Cryptic crossword #139 *Answers*

ACROSS 1 Bras, **3** Baseline, **9** Raising, **10** Lupus, **11** Llama, **12** Shrewd, **14** Myelin, **16** G-force, **19** Agadir, **21** Lemma, **24** Umami, **25** Ganglia, **26** Kedgeree, **27** Orca

DOWN 1 Birdlime, **2** Amiga, **4** August, **5** Euler, **6** In power, **7** Ease, **8** Kigali, **13** Vena cava, **15** England, **17** Feline, **18** Prague, **20** Deice, **22** Molar, **23** Hulk

#27 Dancing decimals *Solution*

1/11 = 0.090909..., with "09" repeating forever. 2/11 = 0.181818... and 3/11 = 0.272727... . The two repeating digits are 9 times the fraction's numerator, so 7/11= 0.636363... and 10/11 = 0.909090... (this repeat occurs because 9 × 11 = 99). 1/7 = 0.142857... (and 142857 × 7 = 999,999, hence a six-digit repeating string). 2/7 = 0.285714..., the same six digits looping but starting from 2. Putting the other options in numerical order, we predict that 3/7 = 0.428571..., 4/7 = 0.571428..., 5/7 = 0.714285... and 6/7 = 0.857142. The thirteenths have two different strings, based on 1/13 = 0.076923... and 2/13 = 0.153846... . Finding all the ways to rotate them and sorting them in numerical order, we predict that 3/13 = 0.230769... and so on.

Nut deficiency

What would happen if you removed most of the nuts from the bolts on three of the four sides of a tall electrical power pylon? New data speaks to that question.

***Newshub* reported on 24 June that a pylon had fallen in Glorit, on New Zealand's North Island, after a "maintenance crew" removed some nuts from bolts connecting the tower to a base plate.**

In the news video, Alison Andrew, chief executive of the Transpower company, reads aloud a presumably carefully worded statement: "Our view is that the specifications and procedures for this type of work were not followed. All the nuts securing the tower to the base plate on three legs had been removed, which caused the tower to lift off the base plate and fall. It is unprecedented and inconceivable that so many nuts were removed at once."

The consequence of the Glorit nuts removal might have been, but apparently was not, predicted by applying textbook engineering principles.

Twisteddoodles *for New Scientist*

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Hold on to your hats

The "poor availability in Ireland of hats" – a phrase featured in a paper in the journal *Clinical and Experimental Dermatology* – refers not to all hats, just to some hats, specifically to sun hats.

Marion Leahy and her colleagues at University Hospital Galway stuck that phrase into the title of their 2022 study about the perilous state of men's heads, especially older men's heads, in the west of Ireland.

They warn that men there are demographically at high risk of melanoma, that these men traditionally protect themselves with hats, but that "most hats available to the male population in Ireland [do] not offer adequate photoprotection".

Properly chosen and properly worn, a hat protects a head from the relentless assault of the sun. In 1992, B. L. Diffey and J. Cheeseman wrote a paean to the goodness of good sun hats and the badness of bad sun hats. Published in the *British Journal of Dermatology*, Diffey and Cheeseman's paper, titled "Sun protection with hats", is famous for – or should be famous for – its main photograph. To cap off your appreciation, track down a copy online.

This portrait of scientific equipment jars with the stereotypical array-of-test-tubes imagery that has, for decades, been inculcated into the minds of children. It shows, at a rakish angle, six plastic, bodyless, hairless artificial heads. They are outdoors, mounted at intervals along a rod 2.4 metres in length. Hats sit on five of the six. Nothing sits on the third head. Each head sports little squares of sunlight-degradable polysulphone film that are affixed with Blu Tack onto the forehead, nose, cheeks, chin and neck.

A second, less avant-garde photo shows "the 28 hats worn in the study", arranged in four rows of seven hats or hatlike objects. The styles range considerably, and include a crownless green plastic visor, an "airline pilot peaked cap", a "checked deerstalker cap" and a "Russian fur hat".

Much of this is dermatological madhattery, Diffey and Cheeseman lead us to believe, on display under the blazing sun.

Spacey superpowers

Bruce Stavert sends a reminder to Feedback's growing collection of trivial superpowers that talent by itself doesn't guarantee success.

He says: "I thought I'd contribute to the discussion on spacey superpowers. My superpower sense of north becomes a superhindrance in the northern hemisphere, where I constantly find myself driving or walking in the opposite of my intended direction.

"Clearly the position of the sun plays a large role in these superpowers. I have to stop and think 'the sun is in the south here' before making any directional decisions. I was in the US at a conference dinner once and was telling an American participant about this problem. 'Does it still rise in the east?' he asked. Mind you, he also found it hard to believe that it was winter in Australia while we were enduring a terribly hot Boston summer."

The Ghod Dam limit

Bapu Deokar and colleagues lay out some Ghod Dam water bookkeeping basics in a paper in the *Asian Journal of Environment and Ecology*, "Estimation of water utilized for washing vehicles in Shrigonda town, India". They explain that as the water level behind the dam plummets, the region's car wash businesses respond by sucking up increased amounts of groundwater. "As a result," the study warns, "the groundwater level is decreasing, leading to a shortage in the volume of groundwater."

Feedback boned up on some Ghod Dam basics by digging up a copy of a should-be-beloved-because-of-its-title study called "Volcanic vents of the Ghod Dam area", published in 1997 in the *Journal of the University of Poona*. It confirms that the Ghod Dam is "near Chinchni, in the district of Poona, in India".

Recently, in the *International Journal of Advance and Applied Research*, Hanumant Dattatray Shinde of Shri Padmamani Jain Arts and Commerce College calculated that, over the course of a year, "up to 1.56 TMC [thousand million cubic metres]" of water evaporates from the Ghod Dam. No matter how you describe it – "Ghod Dam" or just "dam" – the structure passes a lot of water. ▮

Marc Abrahams

Glow-up

With a JJ04 movement capable of precisely plotting each phase of the moon for 128 years, the C1 Moonglow has always had allure. Now, it exerts an even greater gravitational pull. The twin Globolight orbs, which wax and wane across the starry, sapphire dial are more three-dimensional. And, instead of glowing green, they gleam a cool, bright blue - thanks to souped-up Super-LumiNova. (Which also lights up its orbiting date wheel, for truly stellar nocturnal legibility.) Other lustrous features include a 40.5mm LightCatcher™ case, polished lug facets and optional five-link Consort™ bracelet. Even its price is illuminating: from just £1,995 on leather.

Do your research

Christopher Ward

christopherward.com

IN TRIBUTE TO PARIS 2024

The Speedmaster Chronoscope Paris 2024 is a reminder of the expert precision that OMEGA brings to the Olympic and Paralympic Games. Created in the colours of this summer's historic sporting competition, the design is crafted in stainless steel and features a commemorative medallion on the caseback. On the dial, a unique timing track is revealed, with tachymeter, pulsometer, and telemeter scales in a 1940s snail display. A sublime tool for measurement that celebrates our trusted role as Official Timekeeper.

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